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SOIL SCIENCE

BY

KOKICHI SHINJO

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SOIL SCIENCE

by Kokichi Shinjo

Contents

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Preface

As days go by, I painfully feel how incalculable were the material loss and spiritual deterioration suffered throughout and since the defeat in war. And, although food shortage is a root of worry, scarcity of books and contributions which satisfy spiritual need is also a confronting problem.

It is a very pitiful sight, and yet strikingly sacred, to see educators and leaders who collect, refer, and compile diligently until deep of a night in order to fulfill their chosen responsibility, depending primarily on their memories and the few materials which remain of those which they so painstakingly collected in the past. I, for one, deeply express appreciation to those who initiated the timely plan aimed at a compilation of a reference book pertaining to agricultural development.

I was called upon to make a contribution related to "Okinawa Soil" as a part of the compilation. I, myself, am taken aback, however, by the shallowness of this report. This is because of the valuable materials lost by fire, of difficulty in obtaining reference books, and of lack of memory. I would like to rationalize that the

incompleteness of this report was unavoidable because of the existing abnormal situation, but I regret it deeply. Consequently, many errors might have been committed in this report. But I shall endeavor to collect materials and correct them, and I am more than fortunate that I could supplement or revise this report through your extended able assistance. Furthermore, if this report is regarded in any way as a worthy contribution, I am highly honored.

May, 1946

Shinjo, Kokichi

INTRODUCTION

For the survival of mankind, procurement of foodstuff continues to be the foremost problem, among other existing problems, regardless of time, in the past or in the present, or whether the nation be in the western or in the eastern hemisphere. But, especially since the hostility ceased, this threatening problem loomed before us menacingly. Thus, every conceivable effort is directed to cope with the problem which has now become world-wide.

In the past, output of agricultural products of Okinawa was insufficient to fill the demand of domestic consumption. Thus, Okinawa has continued to exist under unstablized situations by depending on imported products from abroad. It is obvious that the food problem will become more critical. In order to alleviate, if not solve the problem, not only the farmers but also the total populace of Okinawa must cooperate to surmount all difficulties, search for the best possible solution, and put an adapted plan into effect.

There are two practiced methods of increasing output of agricultural products: (1) further expansion of tillable land; and (2) increase of output per TAN (1186.14 square yards).

It is an established fact that Okinawa is inhabited by a large population, and that the acreage of cultivated land is small and limited. This is the primary cause for the food shortage. In the eras past, our forefathers have endeavored to seek a solution in order to solve the difficult problem.

They have practically utilized most of the land available, though limited, as rice paddy, field, and garden. Hence, the cultivated land in Okinawa comprises 29 percent of its total area, as compared to 15.7 percent in areas elsewhere.

The percentage of cultivated land reaches an even higher figure in the more confined areas of greater population, as in the following:

Shimajiri	47 percent
Nakagami	61
Kunigami	16
Miyako	57
Mae-yama	10

The above percentage of Shimajiri includes those of Kume and Ihiya Islands. Percentage of Shimajiri alone would be substantially higher. That of the Haebaru District runs as high as 75 percent. Therefore, the area in Yaeyama can be developed further to yield cultivatable land--a serious problem in the future. However, overall observation cautions that there are many restricting

problems confronting this method of increasing agricultural production.

The latter method of increasing output per TAN (1186.14 square yards), accomplished through selection of better seed, more careful nursing of plants, and improvement of planting, is by far a better method than the former. This method will be a contributing factor for increasing the food, and it should be enthusiastically adopted.

It has been said since the ancient time that Okinawa is climatically blessed. But yield per TAN is less than those of other areas, primarily because Okinawa soil is infertile.

The causes for Okinawa soil infertility are as follow:

1. Limited application of organic and inorganic fertilizers.
2. Quick exhaustion and early decomposition of soil nutrients and organic elements due to high temperature and humidity.
3. Loss of fine soil, clay, or colloidal clay, and nutrients in soil by rain, especially by squalls.
4. Removal of large amount of soil nutrients by predominant agricultural products.
5. Absorption of nutrients from the soil by all agricultural products throughout the year.

Thus, doubled, constant effort is necessary to retain or improve the soil, which is gradually being exhausted, not only because of high temperature and humidity but also because of numerous other factors.

Advancing civilization and stablizing livelihood are primarily attributed to exerted efforts of those who have appreciated the value of fertile land. Furthermore, we have learned that a nation has been weakened because people left the soil.

The civilization and prosperity of Okinawa cannot be advanced or gained on the poor and barren land of today. The limited amount of cultimated land has been ravaged by war, and, moreover, repatriates are daily returning to their homes. Unless increased output of agricultural products is shown through better utilization of land, reclamation, and application of fertilizers, rehabilitation of Okinawa will be unsuccessful. All inhabitants of Okinawa must realize that its success or failure depends on their willing cooperation and hard work.

CHAPTER I SOIL, FORMATION OF SOIL

Section A - Soil

Definition of soil: Soft surface soil utilized for agricultural productions and uncultivated soil.

Soil is principally composed of inorganic matter resulting from disintegration or decomposition of rocks; of organic matter derived from decayed plants; and also of air, moisture, and micro-organisms. The amount of organic vs. inorganic material in a soil content determines whether the term organic or inorganic is applied. However, the above is an extreme case. Ordinarily, soil is composed of a mixture in various combinations of organic and inorganic material. Some authorities merely term inorganic soil containing extremely limited amounts of humus as simply earth, and that containing suitable amount of humus as soil.

Fertile land must be acquired in order to increase agricultural production now, an emphasis must be placed on the fact that Okinawa soil lacks humus and is considered earth rather than soil.

Section B - Formation of Soil

Article 1 - Weathering

Under prolonged exposure of rain, wind, and hot and cold weathers, even a hard rock gradually disintegrates

into fine grains. This process is called weathering, and generally can be divided into physical and chemical weatherings.

Physical weathering includes (1) effects of changes of temperature and humidity; (2) pressures exerted by freezing; (3) mechanical actions of running water and wind; and (4) biological actions. Actions of water, carbonic acid, and oxygen constitute chemical weathering. Weathering results from these combined actions, but it is not overstated to say that climatic conditions primarily govern the cause of these actions.

Weathering is extremely aggressive in an area climatically favored and associated with various advantageous conditions. High temperature and rainfall especially expedite the chemical weathering processes and special types of soils are formed under these conditions.

Under these conditions of high temperature, weathering is comparatively rapid and the process of hydrolysis is especially active.

When the action of hydrolysis is high, leaching becomes active and thus the soil base will be lost. Meanwhile, result of continued laterization forms a soil somewhat similar to laterite. This is the reason that most of the Okinawa soil contains less base and less silica.

Comparatively large amounts of iron and aluminum are present. This is more evident in older soil which has been subject to weathering for longer periods of time.

All of the Okinawa soils have gone through the above process. Soils which at present contain substantial amounts of base will in later years become exhausted of these base materials. Thus, although quick weathering does offer a few advantages, it also presents serious problems when improvement of soil is considered.

SECTION C - GEOLOGY, COUNTRY ROCKS, AND SOIL OF OKINAWA

Article 1 - Geology and Country Rocks

From a geological standpoint, Okinawa is stretched in zone of three belts in so-called Ryukyu curve from NE to SW.

The first belt, inner curve, faces East China Sea and originates from Mt. Kaimon, located in southern tip of Kyushu, including Shichi Island, Shimajiri in northernmost tip of Okinawa, Kume Island, Aguni Island, Tonaki, joining Senkaku Archipelago, and terminating at Mt. Daiton in Formosa. Rocks are chiefly younger effusives like pyroxene andesite.

The second belt is the main one, which covers Amami Island, Tokuno Island, Okino-erahu Island, Yoron Island,

the entire Kunigami District, linking Iheya, Izena, and Kerama Archipelagos, Ishigaki Island, passes Takedomi, Kayama, Obama Islands, touches northeastern tip of Iriomote Island, and continues to Formosa. It belongs to Paleozoic Age. Rocks include clay slate, sandstone, augite, amphibolite, limestone, compact quartzite. Older igneous rocks, such as porphyrite and granite, were observed occasionally. This belt is generally mountainous and very steep. Copper ore is produced in limited areas.

The third belt faces Pacific Ocean and includes Nakagami Island, Shimajiri Island, Miyake Island, and majority of Iriomote Island. Rocks are marl and sandstone, Tertiary and Quaternary in age. Terrain is generally rolling. Coal is mined in Iriomote. Surrounding these three belts, raised coral reefs are remarkably developed. In the three belts, there are numerous natural caves, of various sizes, from which phosphatic rock or phosphate is mined.

The Tertiary marl first accumulated on the sea floor and was later uplifted. Marl beds overlain by coral reef are found in hilly areas, road cuts, and in excavations in lower horizon near coral reef. It is believed that marl beds were raised in an area where coral reefs were once formed. Thus, marl surfaces, when first exposed, had no previous vegetation. It is considered that this is a cause for lack of humous matter in the marl, though

the marl gives the appearance of being rich in humus. Tertiary marl, the country rock of Jygaru (dialect) is locally known as 'Kuchia' (dialect). Tertiary calcareous sandstone, the country rock of Ujima (dialect), is locally known as 'Nibi' (dialect), and hard sandstone as 'Nibi no hone', (bone of Nibi).

Article 2 - Soil Classification

Okinawa soils are classified on the basis of color discrimination, a method still widely practiced; that is, grey soil or soils allied in color are called Jyagaru, and red, reddish-brown, yellowish-brown soils or soils allied in color are called Maji. Classified according to its nature, Jyagaru can be further broken down into:

Shimari	Jyagaru	
Kuro (black)	"	
Akamuchiku	"	
Uru	"	
Yaharami	"	etc.

Maji into:

Kuro (black)	Maji
Aka (red)	"
Ishigu	"
Fuegi	"
Furuku	"

and Kaniku into:

Black sandy areas
White sandy areas

The above classification clearly indicates the soil characteristic, but is not scientifically established.

The following chart shows arrangement of Okinawa soils by considering type, parent geological material, and Okinawa district.

Type of soil		Geological formation and country rock	Okinawa dialect
Type of climatical soil	Reddish soil	Kunigami bed (diluvial age)	Kunigami Maji
Type of marl soil; (il-legible)	Terra-Rossa-like soil	Raised coral reef	Shimajiri Maji
		Paleozoic limestone	Kunigami Maji
	Rendgina-like soil	Tertiary marl	Jyagaru Maji
		Tertiary sandstone	Ujima Maji
Type of topographical soil	Skeleton soil	Paleozoic clay slate, etc.	Kunigami Maji
Type of underground Water soil		Alluvial bed	Kaniku

Article 3 - Soil Distribution

A. Tertiary marl soil (Jyagaru - dialect). This soil, the weathering product of Tertiary marl (Kuchiya - dialett), is chiefly distributed in low and hilly areas in Nakagami and Shimajiri Islands. Color of the soil is either gray or a color allied to it. It is distributed largely in Nawashi, Haibaru, Ozato, and in portions of Tomigusuku, Oroku, and Kochinda Districts located in central and northern portions of Shimajiri Island. In Nakagami Island, the soil is distributed in eastern area, namely Nishibara, Nakagusuku, Mizato, Kushigawa, Katsuren Districts, and locally in other areas.

B. Raised coral reef soil (Maji - dialect). This soil, a weathering product of coral reef limestone, is distributed largely in Kujahu, Mahuni, Makabe, Takamine, Itoman, Kanegusuku, Jushigami, Tamagusuku, Chinen Districts; in southern and eastern areas of Shimajiri Island; largely in Urazoe, Ginowan, Chatan-, Yontanzan Districts in western Nakagami; sectionally in Onna, Kin, Motobu; largely in Mujako; and sectionally in Ishigaki Island.

C. Paleozoic Soil (dialect Kunigami Maji). This soil is distributed in Kunigami area, northern Nakagami, Iheya, Izena, Karama, Ishigaki Island, Takedomi, Kayama, Obama, and northern Iriomote. It is principally a reddish

soil (known as Kunigami gravel bed) derived from diluvial material and a terra-rossa-like soil formed as a result of weathering of Paleozoic limestone and Paleozoic soil (skeleton soil) which has been derived from clay slate. Reddish soil characteristically contains rounded or angular pebbles of quartzite. The same soil, either red, yellow, or reddish brown in color, is extensively distributed in Onna, Kin, and all districts in Kunigami Island. Furthermore, it is also seen near villages located adjacent to the northern Kunigami boundary. Ordinarily, this soil overlies Paleozoic beds and coral limestone, and lacks base constituents.

Paleozoic clay slate soil makes up the area from northern Nakagami to Kunigami area and its central mountainous region. The soil includes angular pebbles of clay slate. Paleozoic limestone soil is distributed in Motobu Peninsula, and it is further distributed, though in reddish brown color, in Kunigami District, Akamaru Point, and Hedo Point. These areas have abundant lofty odd-shaped rock, characteristic of a limestone terrain. Soil is infertile.

D. Tertiary sandstone soil (dialect Ujima). This soil was formed as a result of weathering of Tertiary limestone (dialect Nibi). It is locally distributed in Tomigusuku, Urazoi, Nishibaru, and Nakagusuku. It contains

varying amounts of sand, and is infertile.

E. Alluvial Soil. Definition of alluvial soil is given as a marine alluvial deposit, like a sand dune, formed by waves perpetrually carrying fine coral reef grains to shore and depositing them. However, so-called (underground) water type soil, like fluviatile deposit which is formed in a low, flat area adjacent to the sand dune, should be classified under the alluvial soil. This soil is extensively distributed along the coast. Recently formed soil isn't very well suited for agricultural products, but most of the area is fertile and will share an important part in agricultural increase.

Most productive soil to this date is distributed in coastal areas of Yonabara, Nishibaru, Nakagusuku, Mizato on the eastern coast of Okinawa. Other productive areas are the zone extending from Oroku and Tomigusuku to Itoman on western coast of Shimajiri; Mabuni, Tamagusuku, Chinen, Sashiki Districts on the eastern coast; Urazol, Ginowan, Chatan, on the western coast of Nakagusuku; and Onna, Nago, Motobu, Haneji, Ogimi, Kunigami in Kunigami area.

DISTRIBUTION OF SOIL

Name of District, Town	Name of Soil	Tertiary marl soil	Coral reef soil	Paleozoic soil	Tertiary sandstone soil	Alluvial soil
Shimajiri						
Mawashi	D	Most of eastern area	Near Amaku, Asa			
Tomigusuku	D	Almost entire area			Chiba	
Haebaru	D	Entire area				
Oroku	D	Most of eastern area				Coastal area of Kyochi, Omine
Ozato	D	Most of area excluding east coast				Near Yonabaru Coast
Sashiki	D	Most of area				Coastal area between Tsuwako and Chinen
Kanegusuki	D	Most of northern area	Southern area about 1,3			
Kochinda	D	Most of northern area	A portion of southern area			
Itoman	T	Almost entire area				Coastal area
Takamine	D	Small portion of northern area	Most of area			Coastal area

DISTRIBUTION OF SOIL - continued

Name of District, Town	Name of Soil	Tertiary marl soil	Coral reef soil	Paleozoic soil	Tertiary sandstone soil	Alluvial soil
Makabe	D	Almost entire area	Near Kokabura Ishigusuku			
Kiyan	D		Entire area			
Mahuni	D		Almost entire area			Coastal area
Gushichan	D	Small portion of northern area	Most of southern area			A portion of coastal area
Tamagusuku	D	Southeastern area	From central to northern area			Coastal area
Chinen	D	Northwestern and southeastern area	Almost entire area			Coastal area
Nakagami						
Urazoe	D	Eastern area	Most of western area		Near Eiso	
Nishibaru	D	Most of area			Near Anchi	Coastal area
Ginowan	D	Southern & portion of northern area	Most of area			

DISTRIBUTION OF SOIL - continued

Name of District, Town	Name of soil	Tertiary marl soil	Coral reef soil	Paleozoic soil	Tertiary sandstone soil	Alluvial soil
Nakagusuku	D	Most of central area	Northern and portion of central area		Near Toguchi	Eastern coast
Chatan	D		Most of area	Near boundary of Koshiku		
Yontanzan	D		Most of area	East.area		
Guiku	D		Portion of southern area	Most of north area		
Mi zato	D	Kasabaru and Koss areas	Portion of south	Most of north area		Awase Ishikawa
Gushikawa	D	Takaesu	Tengan, Ugata, Kushi gawa	Central area		
Katsuren	D	Near Haebaru area	Coastal area from N to E	Coastal area between N and E coasts		Portion of Western coast
Yonagusuku	D	On isolated islands		Most of area		
Kunigami						
Ch na	D		Projected point in coast	Most of area		Coastal area

DISTRIBUTION OF SOIL - continued

Name of District, Town	Name of soil	Tertiary marl soil	Coral reef soil	Paleozoic soil	Tertiary sandstone soil	Alluvial soil
Kin	D		Kin, Sokei	Most of area		Coastal area
Nago	D			Most of area		Coastal area n. of Miyazato
Kushi	D		Portion of Abe Pt.	Most of area		
Higashi	D			Entire area		
Ogimi	D			Entire area		
Kunikami				Entire area		Coastal area
Haneji	D			Most of area		Coastal area n. of Nakao
Nakijin	D		Coastal area	Most of area		
Motobu Town			Coastal area of peninsula	Most of area		
Ie	D		Most of area	Portion of central area		
Miyako						
Hirara Town			Entire area			

DISTRIBUTION OF SOIL - continued

Name of District, Town	Name of Soil	Tertiary marl soil	Coral reef soil	Paleozoic soil	Tertiary sandstone soil	Alluvial soil
Gusukube	D		Entire area			
Shitaji	D		Entire area			
Irabu	D		Entire area			
Mt. Yae						
Ishigaki Town			Near or in four districts	Most of area		
Ohama	D		Most of eastern coastal area	Most of area		
Takedomi	D		Between Takedomi Kuroshima, Migusuku	Obama, a portion of Iriomote	Most of Iriomote Is.	

CHAPTER II CHARACTERISTICS OF OKINAWA SOIL

Section A - Physical Composition

Article 1 - Physical Component

Soils are composed of grains of various sizes, and the diameter of the grain, physical components in the soils, are factors which determine the classification of these soils. An angular rock more than two millimeters in diameter is called angular pebble (gravel), and a somewhat rounded rock a granular pebble. A fine soil has grains with diameters less than two millimeters. Fine soil is further subdivided into sand (diameters more than 0.01 millimeter), and clay (diameters less than 0.01 millimeter); and sand is further subdivided into coarse sand (2 to 0.25 mm), fine sand (0.25 to 0.05 millimeter), and silt (0.05 to 0.01 millimeter).

Quartz gravel will be mechanically destroyed to some extent with passing years, but its chemical composition will not change noticeably. On the other hand, feldspar or mica gravel gradually decomposes into clay.

The sand in the fine soil is almost insoluble, and, thus, it does act as a nutrient for plants. But it is an important constituent in soil composition, such as making soil porous, reducing stickiness, and facilitating

flow of air and water. The silt in sand is indistinguishable as grains with the naked eye. Its characteristic somewhat resembles clay; so, it is called subclay.

Clay is an extremely fine soil with great absorptive capacity of water. It becomes viscous when wet, and shrinks and cracks when dried. The portion composed of grains less than 0.001 millimeter in diameter in the clay is known as a colloidal component. Such component absorbs a large quantity of water and aids soil composition by improving flow of air and water. Thereby, humous nutrients are retained.

ARTICLE B - Classification on the basis of Physical Components of Soil and Names

This classification is based on the percentage of clay in the fine soil. In the classification, a 'soil type' is a soil with a specific physical composition.

Clay content	'Soil Type'
Less than 12.5%	Sandy soil
12.5 to 25%	Sandy-loamy soil
25 to 37.5%	Loamy soil
37.5 to 50%	Clayey-loamy soil
More than 50%	Clayey soil

The word 'fine' will be prefixed to 'soil type' name when the fine sand or the silt in the sand is greater than two thirds (e.g., fine sandy soil, fine loamy soil, etc.). The word 'light' will be prefixed to clayey or clayey-loamy soil when these soils are extremely porous.

The following words will be used to describe the gravel and humus content:

Gravel content	Descriptive prefix to soil type
5 to 10%	Contains
10 to 30%	Rich
30 to 50%	Remarkably rich
More than 50%	Gravel, angular gravel soils

Humus content	Descriptive prefix
2 to 5%	Contains
5 to 10%	Rich
10 to 20%	Remarkably rich
More than 20%	Mumous Soil

When use of adjectival clause is necessary in order to indicate or describe the content of gravel and humus, a word or a phrase related to the gravel and a word or a phrase related to the humus should follow the soil's name determined by 'soil type' (e.g., fine sandy soil containing humus and gravel; clayey-loamy soil containing angular gravel and rich in humus; sandy soil rich in humus).

ARTICLE 3 - Soil Characteristic of Okinawa

The quality of soil, as determined by scientific analysis, not only governs growth of plants but is also closely associated with agricultural enterprises. Plants grow well in easily manageable loamy soil. Both extremities in textures--that is, sandy soil and heavy clayey soil--are not suitable for the plants.

The following is the general explanation pertaining to 'soil type'.

A. Tertiary Marl Soil

The marl (dialect Kuchiya), the parent material from which this soil is derived is composed of a very fine grain and the resultant soil is grey or a color closely resembling grey, clayey or a heavy clay, and very sticky. Excessive manhours are required to cultivate it. However, the soil is deep and rich in chemical components, especially base, and the soil responds to improvement practices. The resulting effect of mixing sand with the soil is excellent. This method increased agricultural output 10 to 15%. Nishibaru Experimental Station carried out the above method and found 10 to 20% increase. The best result was obtained in a lot which was mixed with two SUN (about 2.38 in.) of sand. This method should be immediately adapted in heavy clayey areas. Mixing of Ujima and applying organic fertilizer are effective. Good drainage systems should be made in most of the low, moist land where flow of air and water is inadequate.

B. Coral Reef Soil

There are many types, but the commonest is a loamy-like to clayey soil. Generally, the soil is light

and porous and easily manageable. Its color is mostly reddish-yellow or reddish-brown. Soil varies greatly in depth, generally shallow with numerous exposures of rock at surface; occasionally, deep soil is found. Due to existing underground caves, the soil cannot retain humidity. An absolute requirement for this soil is the application of organic fertilizer, improvement of irrigational system, and planting of trees to act as windbreaks.

C. Paleozoic Soil

Paleozoic soil is generally of the clayey type, but contains a substantial amount of gravel and sand. Its color is red or reddish-brown. Cultivatable soil is shallow and flow of air and water is unfavorable. Increased application of organic fertilizer and mixing of sand are necessary to improve this soil. Furthermore, deep plowing is considered excellent. But because the lower horizon is highly deficient in humous nutrients, care must be taken to deepen plowing gradually. That is, one SUN (1.19 in.) per plowing with sufficient application of fertilizer.

D. Tertiary Sand Soil

This soil is rich in sand and easily worked, but not very productive. Its color is mostly yellowish-brown.

Application of organic fertilizer andmixing of Tertiary marl soil are considered effective.

E. Alluvial Soil

Sandy areas come under the classification of sandy soil. Soils are easily worked, but dry up quickly. Productivity is generally poor, but can be effectively improved by increased application of organic fertilizer and mixing of clayey material. Large acreages of soil somewhat similar to loamy or to clayey soil are found adjacent to sandy areas in the alluvial soil. This soil is highly productive. Drainage systems are necessary in low, swampy areas.

CHAPTER III CHEMICAL COMPOSITION

Section A - Chemical Composition

Chemical composition of the soil includes the factors humidity, air, inorganic and organic components. Omitting those of humidity and air, I shall make an attempt to explain the inorganic and organic components.

The inorganic component of the soil is an important portion of soil. It consists of silica, aluminum, iron, calcium, magnesium, potassium, soda, phosphoric acid, sulphur, and etc. However, these components commonly appear in oxide form in the soil.

There are two methods to determine the soil component, the first being to determine the total amount of component soluble in hot concentrated H Cl. But by this method, the amount of available ingredients for plants cannot be determined. Therefore, in order to determine the available ingredient, a solution of 1% citric acid or 1/5 normal H Cl is used in place of hot, concentrated H Cl.

Recently, the Neubauer method has been adopted to determine available ingredients by judging from the amount of ingredient absorbed by young plants. Either method cannot be accepted as a perfect one. Consequently, the Wagner method is ordinarily used; that is, to determine the amount of available ingredients by dividing an area into five lots: completely fertilized, non-nitrogen, non-phosphatic acid, non-potassium, and unfertilized lots. The result of experimental planting in these lots decides the amount of the three ingredients available.

ARTICLE 2 - Organic component

Humus constitutes the organic components in the soil. Color is from brown to black, is of amorphous, colloidal compound, and is continuously decomposing. It contains complexed mixture of numerous organic compounds, but principally of humic acid, humus element, and humous peat.

There are many methods available for determining the organic composition of soil. A common method is to determine the total amount of organic material by considering the amount lost on ignition as humous matter. Caution should be exercised in the interpretation of results of this method, because the humous matter so determined may be confused with soluble humus. Method of analysis is totally different for each case. To determine ignition loss, one to two grains of the soil should be heated; the organic matter will be removed and the remaining ash, the inorganic component, will be weighed. Then the water content and weight of ash will be subtracted from the original weight. Simple formula is as follows:

> Sample weight minus weight of inorganic component minus water content equals amount of ignition loss, total amount of organic component.

Another method for analyzing humous matter is to soak the soil in one percent H Cl and then dissolve in 4 percent ammonia liquid. Result obtained through this method is soluble humus. Therefore, the amount of loss on ignition will be larger than the percentage actually indicated.

Okinawa soil is low in humus matter and poor in productivity. In order to improve it, application of

organic fertilizers, especially coarse compost of stable manure and green manure is essential. The green manure is effective in supplementing nutrients.

ARTICLE 3 - Chemical Composition of Okinawa Soil

Recent analyses on chemical composition of Okinawa soils are not available; old analyses are submitted as a reference. (See following page.)

TERTIARY MARL SOIL

Name of village, town	Humous matter	Total nitrogen	Soluble components in hot concentrated H Cl			Available ingredients		
			Phosphoric acid	Potassium	Lime	Phosphoric acid	Potassium	Lime
Tomigusuku	1.95%	0.26%	0.14%	0.45%	2.29%	0.03%	0.03%	0.85%
Tamagusuku	1.25	0.46	0.16	0.51	3.89	0.04	0.03	0.81
Sashiki	2.05	0.26	0.09	0.48	1.11	0.03	0.04	0.60
Ozato	1.55	0.60	0.15	0.32	3.45	0.04	0.04	0.86
Urazol	1.75	0.26	0.14	0.46	1.22	0.02	0.03	0.67
Nishibaru	2.85	0.37	0.33	0.51	1.50	0.04	0.05	0.84
Nakagusuku	1.20	0.74	0.54	0.48	3.09	0.03	0.04	0.97
			CORAL REEF SOIL					
Kanegusuku	2.25	0.28	0.54	0.42	0.23	0.02	0.03	0.48
Mabuni	2.80	0.35	0.14	0.56	0.60	Trace	0.02	0.26
Gushikawa	2.75	0.73	0.26	0.20	0.40	Trace	0.02	0.44
Ginowan	1.20	0.24	0.15	0.14	0.38	Trace	0.03	0.09
Yontanzan	2.20	0.34	0.05	0.08	0.53	Trace	0.03	0.39
Guiku	1.80	0.39	0.51	0.20	0.68	Trace	0.02	0.22
Mizato	2.75	0.30	0.42	0.36	0.98	Trace	0.02	0.27
Yonagusuku	1.95	0.49	0.43	0.23	0.60	Trace	0.02	0.17
Ie	3.51	0.31	0.16	0.40	0.14	Trace	0.02	0.54
Gusugube	2.18	0.26	0.47	0.23	0.94	Trace	0.03	0.12
Ishigaki	2.50	0.54	0.29	0.29	0.10	0.02	0.02	0.21
			PALEOZOIC SOIL					
Nago	2.15	0.28	0.10	0.19	1.70	Trace	0.02	0.40
Kin	2.25	0.28	0.20	0.28	1.24	Trace	0.02	0.20
Ogimi	1.60	0.57	0.03	0.02	1.09	Trace	0.02	0.40
Haneji	3.43	0.27	0.24	0.51	0.86	Trace	0.02	0.07

TOTAL NITROGEN CONTENT

Soils	Maximum	Minimum	Average
Tertiary marl soil	0.157%	0.072%	0.116%
Coral reef soil	0.227	0.070	0.133
Paleozoic soil	0.263	0.005	0.118
Paleozoic red colored soil	0.047	0.010	0.034
Tertiary sand soil	-	-	0.068

As I have mentioned, Okinawa soil is gradually changing into a soil with only relics of basic material. At the present, the soil lacks available ingredients; application of fertilizer is necessary.

A. Tertiary Marl Soil

The Tertiary marl, parent material of the marl soil, is comparatively rich in base, especially lime. Surfaces exposed to weathering soon become leached of their base material. Humus content is lower than that of coral reef soil, despite the fact that the marl soil gives the appearance of being high in humus. Total nitrogen in Tertiary marl soil is not very high, but the phosphoric acid percentage exceeds that in other soils. Surface soil is generally deep. The upper horizon contains more humous matter and nitrogen than the lower horizon, but it appears that the lower horizon contains more base than the upper horizon. However, compositional difference of these two horizons is slight; so, deep plowing is appropriate. Effect of potassium applied

was not considered favorable; however, effect of phosphoric acid and nitrogen was excellent. Application of compost and stable manure is effective, though not as effective as in case applied to Maji soil.

B. Coral Reef Soil

Composition of this soil differs with the age of reefs. That is, new soil on more recent reefs is rich in lime, whereas old soil lacks it. Phosphatic rock or phosphate is mined from coral reef soil in many areas ; yet, the soil seems to lack available phosphoric acid. Although the humous matter content in this soil is not considered high, it seems to exceed that of other soils. The nitrogen content is judged favorable. Surface soil is generally richer in plant nutrients than lower horizon, and there exists a substantial difference between the two. Gradual deep plowing therefore must be carried out with more generous application of inorganic and organic fertilizers. Flow of air and water is excellent, but the soil cannot retain humidity. Addition of potassium and nitrogen is effective, especially stable manure.

C. Paleozoic Soil

This soil is generally highly leached and characterized by an absence of base which has been washed away. The best example of high leaching is the reddish soil.

Humous matter and total nitrogen content of Paleozoic soil in general isn't too low, but it is very low in reddish clay. Because lower horizon greatly lacks plant nutrients in comparison to surface soil, careful plowing must be done. The soil lacks all plant nutrients. Nitrogen, phosphoric acid should be applied, but potassium is most effective. Lime, compost, and stable manure are good, also.

D. Tertiary Sand Soil

Composition of this soil differs depending on location and, accordingly, base content differs, also. Generally, it lacks available ingredients and nitrogen content is negligible. Application of the three essential ingredients--compost, stable manure, nitrogen--is effective.

E. Alluvial Soil

Sandy areas in the alluvial soil are extremely low in available ingredient, especially in the lower horizon. But most of the alluvial deposit soils are composed of various components and, hence, are relatively fertile. Soils are of moderate depths. There is substantial acreage of land which tends to become over moistened, due to higher level of underground water. Sandy area dries up quickly.

SECTION B - CHEMICAL PROPERTIES

Article 1 - Absorptive Capacity of the Soil

Absorptive capacity of a soil is the capacity of the soil to absorb and retain matter in the solution. If the

lacks this peculiarity, application of fertilizer will be useless, because the fertilizer will be washed away by rain before being absorbed. The colloidal clay, humus, and calcium carbonate in the soil primarily govern the above action. Therefore, the absorptive capacity will be greater if the soil is the clayey, loamy, humous soil, and will be lower if the soil is a sandy or gravelly type. Amount of base-ion and acid-ion to be absorbed by the soil differs greatly, according to its type. That is, ammonia and potassium in the base ion will be readily absorbed; magnesium and lime not quite so readily, and soda least readily. Phosphoric acid and carbonate in the acid-ion are greatly absorbed, followed by sulphuric acid and chlorine, and, lastly, very limited amounts of nitric acid.

Simple formulas are:

Base-ion: potassium, ammonia $>$ lime

magnesium $>$ soda

Acid-ion: phosphoric acid, carbonate $>$ sulphuric acid $>$

chlorine $>$ nitric acid.

SECTION B - THE REACTION OF THE SOIL

The soil is ordinarily neutral; however, it shows acidic or alkaline reactions. Thus, the soil is generally divided into acid and alkaline soils.

A. Acid Soil

There are two kinds of the acid soils. In one of them, the acidity is due to the presence of a free acid or acid salt, both of which produce an active acidity. In other acid soil, inorganic matter is present without soluble acid salts, but included are inorganic colloidal multiple compounds unsaturated by basic water. When these are met by neutral salts, acid substances are freed.

B. Indication of Acidity

The most simple and commonly used method for determining the intensity of acidity is by the use of lithmus test paper. The next method is by titration. A recent method is to indicate it with adoption of PH, which expresses the acidity in terms of the hydrogen-ion concentration. The value of the PH is the index number of the hydrogen-ion density. Detail explanation pertaining to the above will be omitted. Pure water is neutral and is PH 7. The relation between PH and reaction is as follows:

```
   (0 1 2 3 4 5 6      - acidity
PH (             7     - neutral
   (8 9 10 11 12 13 14 - basicity
```

The acidity decreases as the number lessens down from 6. The basicity increases as the number rises from 8. Moreover, PH 4 corresponds to the acidity when ~~xx~~ 1/10 normal hydrochloric acid is diluted 1000 times. PH 10 corresponds to

the alkalinity (alkaline density) when 1/10 normal caustic potash is diluted 1000 times.

C. Hydrogen-ion concentration and Growth of Crops

It is widely recognized that the soil reaction is one of essential factors in influencing the growth of crops. Much research has been concerned with the above, but conforming opinion has not been established. However, it is generally accepted that a neutral or nearly neutral reaction greatly aids growth, but area with high acidity or basicity injures the growth. Detailed observations reveal that the influence of the reaction somewhat differs according to variety of crop. Accordingly, Dr. Daikubara once classified the crops into five groups, each having a different capacity of resistance against the acidity.

1. Most strong in resistance for acidity: flooded paddy rice, dried land rice, oat.
2. Strong in resistance for acidity: wheat, millet, corn, buckwheat.
3. Somewhat strong in resistance for acidity: coleseed, Komatsu colza (J. P.), horse bean, tomato, radish.
4. Weak in resistance for acidity: eggplant, pepper, rye, pea, clover.
5. Most weak in resistance for acidity: barley, spinach, Chinese milk vetch, soy bean, red bean, kidney bean.

Usually the PH of the soil ranges from 3.8 to 8.5. In the soil excluded from the above scope, very few plants will grow. Furthermore, the range of optimum reaction for the plant growth is considerably narrow.

The following chart shows PH for each crop.

Crop	Optimum	Crop	Optimum
Flooded paddy rice	4.0-7.0	Hairy vetch	7.0
Dried land rice	5.0	Alfalfa	7.3-8.1
Rye	5.0-6.0	Chinese milk vetch	5.9-8.0
Barley	6.0-8.0	Tomato	7.5-8.0
Wheat	6.3-7.6	Eggplant	6.8-7.3
Oat	5.3-7.9	Watermelon	5.5-6.1
Soy bean	6.3	Komatsu colza	5.0-6.0
red bean	4.5-4.6	Lettuce	5.0-6.9
Horse bean	6.7	Turnip	6.0
Kidney bean	7.0-8.0	Cabbage	6.1-6.7
Sweet potatoes	6.1-7.8	Cucumber	7.0-7.2
Millet	4.9-6.2	Cotton	4.9
Corn	6.0-7.0	Tobacco	5.0-5.5
Lupin	4.0-6.0	Colza seed	5.6-7.1
Celladella	5.4-6.5	White sesame	4.5
Red clover	6.0-8.0	Buckwheat	6.5
Zatwicken	7.0	Beet	7.0-7.5
Pea	6.0-7.0	Tea orange	4.5-5.0
Potato	4.9-5.6	Unshu mandarin/	5.0-6.0
Kaoliang	5.5	Shichito rush	6.2-7.0

ARTICLE 3 - REACTION OF SOIL

Regional reaction of Okinawa soil

Name of District, Town	Name of Soil	Soil Point	Maximum PH Distillated Water	Maximum PH K Cl	Minimum PH Distillated Water	Minimum PH K Cl
Shimajiri						
Mawashi	D	2	7.60	6.38	5.80	5.59
Haebaru	D	3	7.40	6.86	6.93	5.87
Tomigusuku	D	2	7.93	6.15	7.15	6.21
Kanegusuku	D	3	7.32	6.35	6.95	6.05
Itoman Town		3	7.47	7.15	5.73	-
Makabe	D	3	7.35	6.53	6.31	5.31
Kiyabu	D	1	7.15	6.86	7.15	6.86
Mabuni	D	1	7.89	5.74	6.89	5.74
Gushikami	D	3	6.74	5.76	5.74	5.38
Tamamike	D	1	7.02	6.78	7.02	6.72
Kochinda	D	3	7.49	6.77	7.21	6.47
Tamagusuku	D	13	6.95	6.08	5.46	4.87
Chinen	D	6	7.42	6.49	5.38	4.80
Ozato	D	2	6.88	5.67	6.15	5.40
Sashiki	D	2	7.40	7.02	7.40	6.61
Nakazato	D	1	7.20	6.98	7.20	6.98
Gushigawa	D	2	6.64	5.47	4.25	3.76
Zamami	D	4	6.61	5.47	5.37	4.46
Iheya	D	6	6.36	5.56	3.54	2.92
Oroku	D	2	7.39	6.74	7.15	6.47
Shuri						
Hirara Town	1	1	7.23	6.56	7.23	6.56

Name of District, Town	Name of Soil	Soil Point	Maximum PH		Minimum PH	
			Distillated Water	K Cl	Distillated Water	K Cl
Nakegami						
Urajol	D	6	7.40	6.40	6.45	5.03
Ginowan	D	14	7.49	6.98	6.82	5.20
Chatan	D	10	7.38	6.74	4.67	3.55
Yontanzan	D	11	7.78	6.61	4.57	3.71
Nishibaru	D	3	7.32	6.63	7.27	5.86
Nakagusuku	D	16	7.40	6.63	5.30	4.45
Guiku	D	14	7.58	6.13	4.43	3.52
Mizato	D	7	7.63	6.87	6.15	5.45
Gushigawa	D	4	7.25	5.97	6.54	5.59
Katsuren	D	4	7.38	6.12	6.28	5.22
Yonagusuku	D	3	7.21	6.63	6.12	5.09
Kunigami						
Onna	D	7	7.28	-	4.44	3.95
Nago Town		3	6.73	5.95	6.31	5.64
Haneji	D	13	6.89	5.80	2.92	2.92
Ogimi	D	5	6.39	5.80	4.45	3.15
Higashi	D	4	6.89	6.05	4.71	3.89
Motobu Town		4	7.03	6.44	5.75	4.65
Kin	D	3	6.38	5.14	5.81	4.42
Ie	D	8	6.86	6.14	6.11	5.31
Mujako						
Hirara Town		8	7.03	6.84	4.21	3.76
Gusukube	D	12	7.07	6.34	5.15	4.45
Shitaji	D	4	6.93	6.08	5.20	4.71
Irabu	D	2	6.61	5.96	6.20	5.88
Yaeyama						
Ishigaki Town		5	7.19	6.14	5.12	4.55
Ohama	D	7	6.68	6.14	4.79	3.95

The hydrogen-ion concentration of the 250 sample soils collected from the above 44 localities were tested by ITANO Model PH testing apparatus. The result is that the Tertiary marl soil (dialect Gjagaru) is almost neutral or slightly acidic, and rarely acidic. Therefore, acidic plants such as lupin and tea do not grow well. The coral reef soil (dialect Shimajiri Maji) is almost neutral, slightly acidic or slightly basic, and seldom acidic. The Paleozoic soil (dialect Kunigami Maji) is for the most part slightly acidic or acidic and in a few places highly acidic. This mostly applies to reddish soil and marl soil which is suitable for tea and lupin.

The Tertiary sandy soil (dialect Ujima) is generally divided into two types:

1. Neutral to slightly basic.
2. Slightly acidic to acidic.

The alluvial soil (dialect Kaniku) is neutral to slightly basic.

ARTICLE 4 - IMPROVEMENT ON ACIDIC SOIL

1. ~~To~~ Neutralize the acidity with application of lime; approximately 20 KAN (about 165 pounds) to 60 KAN (about 500 pounds) of commercial lime per TAN are used. But because Okinawa soil is weak in buffer action,

15 KAN (about 124 pounds) to 20 KAN (about 165 pounds) of commercial lime must be applied at a time, and applications must be repeated until it is considered sufficient.

2. Apply calcium carbonate--that is, powdered lime--as a substitute for commercial lime.

3. Apply ash of wood in place of the lime. This will correct the reaction and at the same time supplement the potassium.

4. Avoid application of animal manures.

5. Apply compost and stable manure as much as possible.

6. Cultivate frequently to facilitate flow of air and water.

7. Improve drainage system.

CHAPTER IV MICRO-ORGANISM IN THE SOIL

Section A - Micro-organism in the Soil

It is estimated that 380,000 bacteria thrive in one gram of sandy soil found close to the surface, and 500,000 to 1,000,000 in the loamy and clayey soils. Filiform and fissioning bacteria are the principal ones which are closely related to the growth of plants. Multiplication and activity of the bacteria can be expedited if conditions related to temperature, air, humidity, and nutrient are improved.

A. Temperature

Temperature limit in which the bacteria remain active is considerably wide. When the soil freezes, the bacteria cease their activity, but do not die. The bacteria become increasingly active as the temperature begin to rise from above the freezing point and become inactive when temperature registers 40 to 70° C.

B. Air and Humidity

Demand differs for air and water for aerobic and anaerobic bacteria. The aerobic bacteria thrive in soil where water is insufficient and air is sufficient. The anaerobic bacteria flourish in soil saturated by water or in area where oxygen in the soil has been changed into carbonic acid gas.

E. Nutrients

Soil bacteria subsist on carbon and nitrogen in certain organic compound. Multiplications and types of bacteria are governed by progressive steps of decomposing organic matter.

Following are the principal causes which influence the number of soil bacteria:

1. Utilization of area: number of bacteria increases in order listed--forest, cultivated land, residential area.

2. Type of soil: bacteria generally thrive less in sandy soil than in soil rich in clay or humous matter.

3. Cultivation and application of fertilizer: Bacteria thrive in greater number in well cultivated soil which has had frequent application of organic fertilizer, than in cultivated soil without the same application.

4. Reaction of soil: Bacteria thrive in greater number in neutral or slightly alkaline soils than in acidic soil.

5. Depth of soil: Bacteria thrive more in upper horizon of soil than in lower horizon of soil, especially in 20 to 25 cm. depth. Very few are found at a depth of one meter and none under 3 meters depth.

6. Climatic: Bacteria thrive in greater number in summer than in winter, and greater in rainy season than in dry season.

SECTION B - ACTION OF MICRO-ORGANISM

A. Action of Filiform Bacteria in Soil

Dominant filiform bacteria in the soil belong to Fuzalium, Aspelgirus, Penicillin, and Radio families. These bacteria actively decompose fibrin and ammonify nitrogenous organic matter. But the ammonia and nitrate-

type nitrogen will be absorbed by the bacteria which delay formation of ammonia in the soil. These thrive in an area where air ventilation is somewhat insufficient. Application of stable manure and acidic fertilizer will aid the multiplication of the bacteria, but lime will decrease them.

B. Action of Bacteria in Soil

1. Ammonification: The action of the bacteria governs the decomposition of organic matters in the soil, and there are many types of bacteria which decompose nitrogenous organic matters, but I shall divide them into aerobic and anaerobic bacteria. Among these, there are bacteria which directly decompose albumen into ammonia and indirectly decompose a decomposed product into ammonia. That is, all nitrogenous organic compounds will be decomposed and ammonified by the actions of the bacteria. Aerobic bacilli most vigorously carry out ammonification in field and rice paddy, either neutral or slightly alkaline. Application of fresh rice straw will frequently but temporarily decrease ammonia productivity. Underground drainage and suitable amount of lime will expedite the decomposition of organic matters and facilitate ammonia productivity. Ammonia in the soil will be noticed more quickly when the anaerobic bacteria act to ammonize rather than if the aerobic bacteria decompose the matters.

2. <u>Nitrification:</u> Ammonical nitrogen in the soil will be acidified by the bacteria and change to the HNO_3 form. The nitrification is carried out by two types of bacteria. That is, nitrobacteria and nitrite bacteria.

The nitrification is done by mutual action of these bacteria. The nitrifying bacteria, aerobic, exist in upper horizon where drainage and ventilation are favorable, and exist seldom or not at all in a rice paddy.

3. <u>Denitrification:</u> The nitrate reducing bacteria emits free nitrogen or similar element by reducing nitrate type-nitrogen in the soil. These bacteria thrive in soil where air ventilation is regarded as poor, especially in soil rich in humus, and in soil where generous amounts of fresh stable manure is applied. Farmers must rid the soil of this bacteria by improving drainage systems, by better ventilation by frequent cultivation, and by not applying excessive amounts of fresh organic matter.

C. FIXING OF FREE NITROGEN

Higher plants cannot directly absorb free nitrogen from the air, buta type of micro-organism can first utilize and then change it into a compound-form. From

an agricultural standpoint, it is a very significant fact that nitro-compound thus fixed by the action of the micro-organism will be available as a nutrient for crops. Nodule bacteria and azotobacter are the principal micro-organisms which fix the free nitrogen.

1. Nodule bacteria: The root of a leguminous plant acts as a host for the hodule bacteria. That is, the bacteria enter within the root and expedite divisional multiplication of interior cells and thus form a nodule. The bacteria in the nodule are aerobi bacilli. These bacilli penetrate into the nodule and multiply by subsisting on carbohydrates supplied by the host. As a reciprocal favor, the bacilli in turn fix a large amount of the free nitrogen in the air and offer it to the host. Under favorable conditions, three KAN (about 24.8 pounds) of nitrogen per crop per TAN can be fixed through the intermediary action of nodule bacteria. Most of the nitrogen thus fixed will be utilized by the host. The roots and nodules remaining in the soil will putrify into nitrogen which will be absorbed by the next crop. Farmers have found from experience that a crop grows well in a field in which a leguminous plant has been previously planted. It is an effective

method to inoculate the nodule bacteria of grass to an area where growth of grass is unfavorable or in an attempt to increase productivity. This is known as inoculation.

2. Azotobacter: These bacteria will thrive in a warm area better than in a cold area, and in soil rich in lime; they do not thrive so well in an acidic or sandy soil. The azotobacter exist independently and increase nitrogen content in the soil by fixing the free nitrogen in the air. There are conditional differences as to the annual amount of nitrogen which can be fixed by this bacteria, but its estimated average is 700 MOMME (92.59 pounds) per TAN. Sufficient application of non-nitrogenous compounds, phosphoric acid, and lime and thorough cultivation of soil for better ventilation will aid greatly the multiplication of this bacteria.

CHAPTER V FERTILITY AND IMPROVEMENT OF SOIL

From the standpoint of agricultural management, acquirement of fertile soil is requisite. Therefore, one of the leading missions of soil science is to improve the soil. Generalization cannot be made due to

complex and inter-related conditions which govern improvement of the soil, but the following are the main ones:

1. Terrain and soil bed: Land should be level. Suitable location of underground water level and favorable relation between surface and sub-soils.

2. Physical structure and property: Proper porosity of soil with appropriate sand and clay contents. Good flow of air and water without becoming excessively dry.

3. Chemical composition. Proper content of humous matter. Greater absorptive capacity. Large amount of available nutrients without organic component. Neither strongly acidic nor alkaline.

4. Micro-organism: Healthy multiplication of beneficial micro-organisms and exclusion of harmful bacteria.

Section B - Improvement of Soil

The number of corrective measures available for improvement of terrain and soil bed in fertility is limited. But remarkable improvement can be made on conditions related to physical and chemical properties

of surface soils. Following three measures are generally adaptable:

1. Physico-chemical improvement: Pertains to works involving mechanical operations, such as harrowing, plowing, pressing, and mixing of one soil to another. The last of these is most effective. This method was carried out on a small scale because it usually involved difficulty in transporting tons of sand or clay. However, it should be widely practiced.
2. Chemical improvement: This means manuring in broad sense. That is, to supplement deficient nutrients and organic matters by direct application of fertilizer, and to correct soil reaction by neutralizing harmful matter to harmless matter.
3. Engineering improvement: Engineering works connected with irrigation, drainage, amelioration, mud precipitation method, and utilization of dry beaches. This method is extremely effective in the places such as Okinawa, where land is limited, and should be vigorously pursued.

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REPORT OF GEOLOGICAL AND MINERAL SURVEY ON
EASTERN CAROLINES - KUSAIE AND PONAPE ISLANDS

by Iwao, Shuichi, technician
Geological Survey Branch

compiled, July 1941

Note: Village* - is used in sense of township
JP indicates Japanese phonetic spelling.
(((---))) words supplied by editor.

ABSTRACT

Receiving instructions from the South Sea Governmental Office, I participated from 20 Jan 1941 to 10 April 1941, period of roughly three months, in geological and mineral surveys on the portion of Kusaie Island, and the western half of Ponape Island; six days from 11 February 1941, to 16 February, on the former; and approximately 40 days - from 18 Feb to 29 March on the latter islands. Although the primary object of the survey was the discovery of mineral deposits other than residual ones, within the area we surveyed such mineral deposits are non-existant. As an alternative, the following report regarding general geology and residual deposit (bauxite and limonite) was made.

Correct figures must be fixed after more detailed study (((of the analyses.)))

Accompanying technicians: Shinoki, Yasuo, Geological Survey Br.
Suzuki, Shota, South Sea Governmental Office
Okuwa, Tyoichi, Assistant Tech., South Sea Governmenal Office
Fujimoto, Kuraichi

KUSAIE ISLAND

The area of geological study on Kusaie Island was confined to the northern side of Mt. Baucha in Tafonsak Village* situated in northern portion of the island and to the area upstream on Wukat and Innem Rivers.

The area is primarily composed of alternation of alkalic basalt, its lava and its agglomerate; and basalt (vein) dikes are frequently observed in the agglomerate. Development of the agglomerate is truly remarkable. Trachy-lava and tuff forming a basaltic foundation is found in areas near the upstream (((headwaters))) of Wukat and Innem Rivers. However, material for an attempt to establish the texture of the original rock is lacking due to extreme decomposition and weathering. There are two or three quartz veins, however, these offer no encouragement for prospecting.

WESTERN HALF OF PONAPE ISLAND

1. GEOLOGY

Geology of the western half of Ponape Island can be generally divided into two classes (1) bottom - lava of aegirine augite, trachy-andesite and its tuff, (2) top - alkalic basalt lava and its agglomerate and tuff. Aegirine-augite, trachy-andesite is found exposed in the area near the middle reaches (stream) of Ronkiti River and near Butoi, both in Kiti Village*. Its lava is light, purplish brown or light greenish grey, and possesses somewhat risinous luster, and is comparatively porous. Its tuff is white or light yellowish to white and poorly consolidated. Tuff is interbedded with lava. Alkalic basalt lava and its agglomerate and tuff which cover the above two rocks, are extensively found in the western half of Ponape Island. From the center of the island,

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alternation of these lavas, agglomerates, and tuffs fan out toward sea with low angle dip of 20° to 5°. Excellent development of agglomerate is found in general locality of Jokaj Village", north of Palang in Kiti Village", and east of Butoi. Other localities are generally of regular alternation of lava 3.4 to 5 meters thick, agglomerate 2.3 meters thick, and tuff. Although most of the rocks belong to augite olivine basalt type, that found in Tean Plateau belongs to basanitoid type and has uniquely weathered surface. Color is dark greenish - grey, or dark bluish grey, and is compact and hard. Ponape Island is a good example of dissected aspiconide volcano.

2. ORE DEPOSITS

No other ore deposits than limonite and bauxite deposits occur in the western half of Ponape. Both the limonite and bauxite deposits are residual, created by the weathering of aforementioned basalts, and are found in level or gently sloping areas.

The relation of the above two deposits, locality and source rocks is illustrated in MAP #4. That is, limonite and bauxite deposits are interbedded over the basic rocks: sequence of zones top to bottom: 1) surface soil, 2) limonite deposits, 3) bauxite deposits, 4) kaolinized clay containing small numbers of bauxite nudules, 5) weathered rock and, 6) bed rock. The surface soil is generally very thin, and in an area where a deposit is well developed, the ore deposit is commonly exposed. Thickness of limonite deposit is from 10 cm more or less to several tens of centimeters deep, but rarely reaches 1 meter. Thickness of the bauxite deposits is from 20 to 80 centimeters but averages 30 centimeters. Although nodules of bauxite are included in upper port of kaolinized clay, the greatest % of the zone is iron oxide and hence is reddish, bluish grey

or yellowish brown in color; maximum thickness is 10 meters. There is a gradual transition from weathered rock to clay. However, the weathered rock shows an earthy luster while retaining the texture and structure of original rock.

A. Limonite Deposits - Refer MAP #3

(1) High grade deposits are found cheifly near Tolonia (or Ipat) north of Mr. Aumar, Tean (or Tamatamansakir) plateau, level surface and gentle slope area located between Tean Plateau and Mt. Nanukawat.

(2) Low grade deposits are found near the aforementioned areas and on the gentle slope area south of southern Kiti Village".

(3) Limonite ore: The deposits are massive boulders, maximum diameter of which is 0.5 meters but average is 10 centimeters, intermingled with granular (pebble-like) ore, diameter of which is 0.5 to 1 centimeter. The massive boulders are either slaggy or honey-combed. In portions of these two types are, small angular pebbles of limonite-stained weathered rock are found. It can be concluded from the above that a section of this deposits was created through a reprecipitation process in an area of residual limonite. Microscopic study revealed that the ore is a hydro-ferrous oxide, gibbsite, and small amounts of quartz and silicate type minerals. The size of the granular ore (((microscopic grains))) is generally from 0.025 to 0.05 mm.

(4) Grade, chemical composition, specific gravity, and area from which samples were gathered are as follows:

Sample Number	Fe	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	MnO	CaO	P_2O_5	S	$+H_2O$	Sp. Gr.
Po 54	49.97		4.82	10.82							3.56
Po 20	47.51		12.31	5.82							
Po 69	46.73										
Po 200	42.20			5.81	1.79	0.11		P=0.66	0.02		
Po 5P	40.56										
Po 22	39.44										
Po 86	36.31										
Po 201	35.99			2.66	2.07	0.09		P=0.34	0.04		
Po 5	35.41	50.63	23.30	2.22	0.80	0.49	0.01	0.37		21.70	2.70
Po 93	31.83										

	TYPE	AREA
Po 54	Limonite massive	East of pineapple ranch operated by South Sea Colonization Co in HARUKI Village* (JP).
Po 20	Honey combed limonite massive	Level ground between Tean Plateau and Mt. Nanukawat (Tolocoline)
Po 69	-- do --	Tean Plateau
Po 200	Bog iron ore (Mr Otsuki)**	Mant Island
Po 5P	Granular limonite	West of Ipat
Po 22	Staggy limonite	Level ground between Tean Plateau and Mt. Nanukawat
Po 84	-- do --	Shalapuk, Kiti Village*
Po 201	Bog iron ore (Mr Otsuki)**	Kiti Village*
Po 5	Slaggy limonite***	West of Ipat (same area with Po 59)

Footnote: ** Reference to: Mr Otsuki Yonosuke's Geology and Mine Products of South Sea Island, Geological Research and Report No 54. Published 1925.

*** limonite deposit with stained schist.

The iron content indicated from the above analyses is not necessarily to be considered low (in content) since, (excluding those of the southern areas) it is rich in phosphorus content.

The refining process which should be used for (((smelting))) it, is the Japanese style Thomas Method.

(5) Ore Reserve: Due to the very limited number of days alloted for this survey, correct calculation of ore reserve is impossible. However, the following estimated metric tonnages were obtained, based on a supposition that the iron ore bed is 20 centimeters thick with a specific gravity of 3.0 (high grade ore) and 2.7 specific gravity , since both are gravel-formed beds:

A. High grade ore - 400,000 metric tons

B. Low grade ore - 7,000,000 metric tons

B. Bauxite Deposits - Refer MAP #3.

(1) High grade deposits with thick beds are found in northern areas, and high grade deposits with thin beds are found in Tean Plateau and southern Kiti Village". Other deposits are thin, and bauxite content is poor.

(2) Ores: Maximum diameter of deposit is 10 centimeters. Generally of sponge-like or irregular nodular bauxite averaging 3 to 4 centimeters and irregular finger-like bauxite with clay averaging 0.5 centimeter in diameter and 3 to 4 centimeters in length. At times platy bauxite is found in cracks within the clay. Frequently bauxite along is exposed above ground surface due to removal of clay by rain and running water. Although the thickness of bauxite deposits differs greatly, as was mentioned, average thickness of those in northern areas is approximately 70 centimeters, those in the level ground between Tean Plateau and Mt. Nanukawat are 20 to 30

centimeters, those of other localities are about 10 centimeters.

Weight ratio of bauxite in clay-bauxite deposit is 2.3%.

Following chemical analysis was performed by the South Sea Aluminum Mining Company.

Areas		Number of Samples Analyzed	Al_2O_3	Fe_2O_3	SiO_2
Palikir	Grassy plain near shrine	37	39.6	35.57	1.44
	Grassy plain near elementary school	16	37.0	30.53	1.47
	Grassy plain of horse training center	20	35.6	32.86	1.00
		Total	Aver.	Aver.	Aver.
	Total and averages	73	38.0	39.19	1.32
Shalapuk		12	30.6	30.18	6.38
Central Mountain Areas and a section of Matalanim Village*	Mt. Manalaut	12	21.4	46.94	1.71
	NINANI, NEPICHI (JP)	13	36.0	26.82	3.50
	Bakanotu	27	32.9	31.66	5.42
		Total	Aver.	Aver.	Aver.
	Total and averages	52	31.0	33.66	4.08
Ranch of South Sea Developement Co. in Matalanim	Various places	13	40.2	22.57	2.44
	Retau	11	37.9	23.82	4.33
		Total	Aver.	Aver.	Aver.
	Total and averages	24	39.2	23.4	3.31
Ipat Area	Town area and Meitik	13	38.6	24.93	4.23
	Tolonia	20	39.3	16.13	12.80
	HANPONMARU (JP)	16	39.3	27.77	0.90
	Nanpil area	24	37.2	27.07	2.33
		Total	Aver.	Aver.	Aver.
	Total and Averages	73	38.5	23.83	4.48
Platue of U Village		15	41.4	19.56	7.96
		Total	Aver.	Aver.	Aver.
	Grand total and averages	249	36.6	27.44	3.64

Footnote: Each sample washed and analyzed was larger than 30 meshes.

Areas	Number of Samples	Al_2O_3	Fe_2O_3	SiO_2
Areas between Tean Plateau and Mt. Nanukawat	2	54.20	8.65	1.13
ECHENRAN (JP)	1	52.50	13.09	0.90
AIRUKA (JP)	1	56.86	8.97	5.80
Tolonia	12	50.46	10.33	3.86
KIYOSHI Argicultural Station (JP)	8	56.45	8.00	6.18
Ipuak Plateau	44	49.51	12.93	5.53
Nanpil	8	53.03	9.25	8.43
Meitik	5	48.47	11.92	12.86
RAAN (JP)	3	54.83	9.82	6.18
Average		50.86	11.61	6.19

Footnote: Above are high grade samples, so same method was adopted as above.

The following is the analysis of bauxite over 2 mm in diameters gathered from various localities and washed before analyzed

Number of Samples	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	$+H_2O$	Specific Gravity
Po 22b		59.92	4.50			
Po 21		59.59	5.15		25±	
Po 67		57.69	3.10			
Po 95		53.63	3.95		to	
Po 51bottom	18.04	51.36	2.10			
Po 51center	19.96	47.89	3.50		30±	
Po 51 top	27.89	42.56	1.85			
Po 11	25.20	33.80	11.40	0.55	27.84	2.18
Po 53		31.00	1.00			
Po 44	51.[illegible]	22.60	5.70			

Sample No.:		Area
Po 22b : Po 21 :		From area between Tean Plateau and Mt. Nanukawat
Po 67		From area near pulp factory in Jokaj Village*
Po 95		From area 3 km north of Palikir in Kiti Village*
Po 51 bottom	bottom layer :	From school ground in HARUKI Village* (JP)
Po 51 center	center layer :	
Po 51 top	top layer :	
Po 11		Western section of HARUKI Village*
Po 53		From Pineapple ranch of South Sea Developement Co. in HARUKI Village* (JP)
Po 44		From area north of Tean Rock

Average diameter of the bauxite is from 0.01 to 0.03 mm, and is associated with gibbsite, limonite, quartz and impurities such as rutile, etc. Judging from the above, this ore can be termed gibbsite - type ore, rich in iron and silica. When compared with those of Palau, BINTAN (JP) (((NEI?))), the alumina content of this ore doesn't differ greatly but the high silica content is not favorable. Moreover, the ore grains are very small in diameter, and it is necessary to grind it down to less than 100 mesh in order to concentrate the ore by flotation process.

In order to determine the grades of ore in top and bottom sections of the bed in bauxite deposits, an analysis was attempted on the sample gathered from top, center, bottom section of bed in the school ground in MARUKI (JP) Village*. As was clearly indicated in the table, the sample from the top section of the bed is rich in iron and the bottom section of bed is rich in alumina.

Estimated ore reserve, calculated on Sp. gr. of 2 for entire bed, is as follows:

> 400,000 Metric tons of ore averaging 25 %, bauxite content.
>
> 150,000 Metric tons of ore averaging less than 15 % bauxite content.

3. CONCLUSION

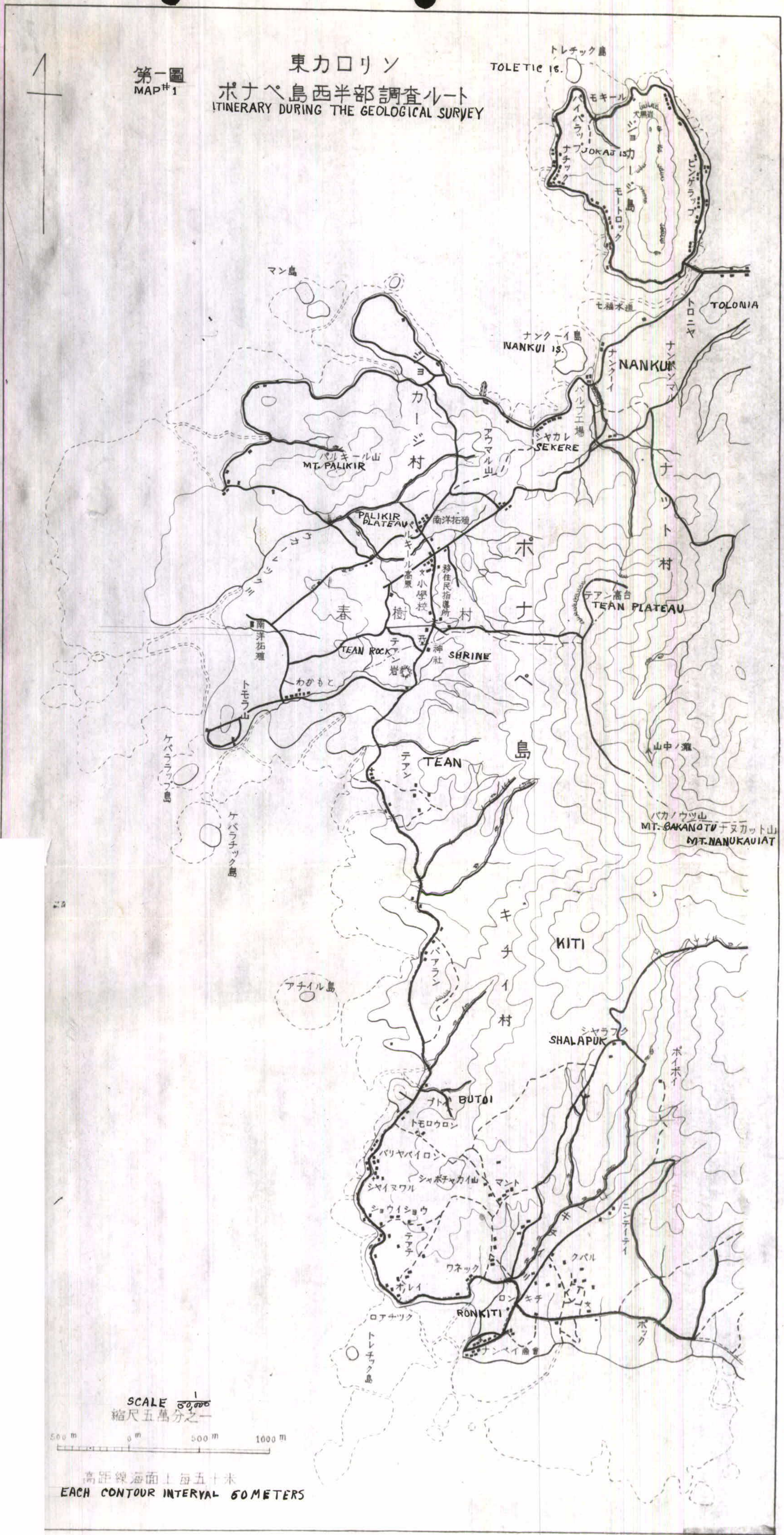
Deposits, other than the limonite and bauxite within the areas which we surveyed in northern Kusaie Island, and western half of Ponape Islands, are non-existant.

Residual deposits of bauxite in Ponape Island are extensive and those relatively high grade deposits, worthy of mining, are distributed in the northern half.

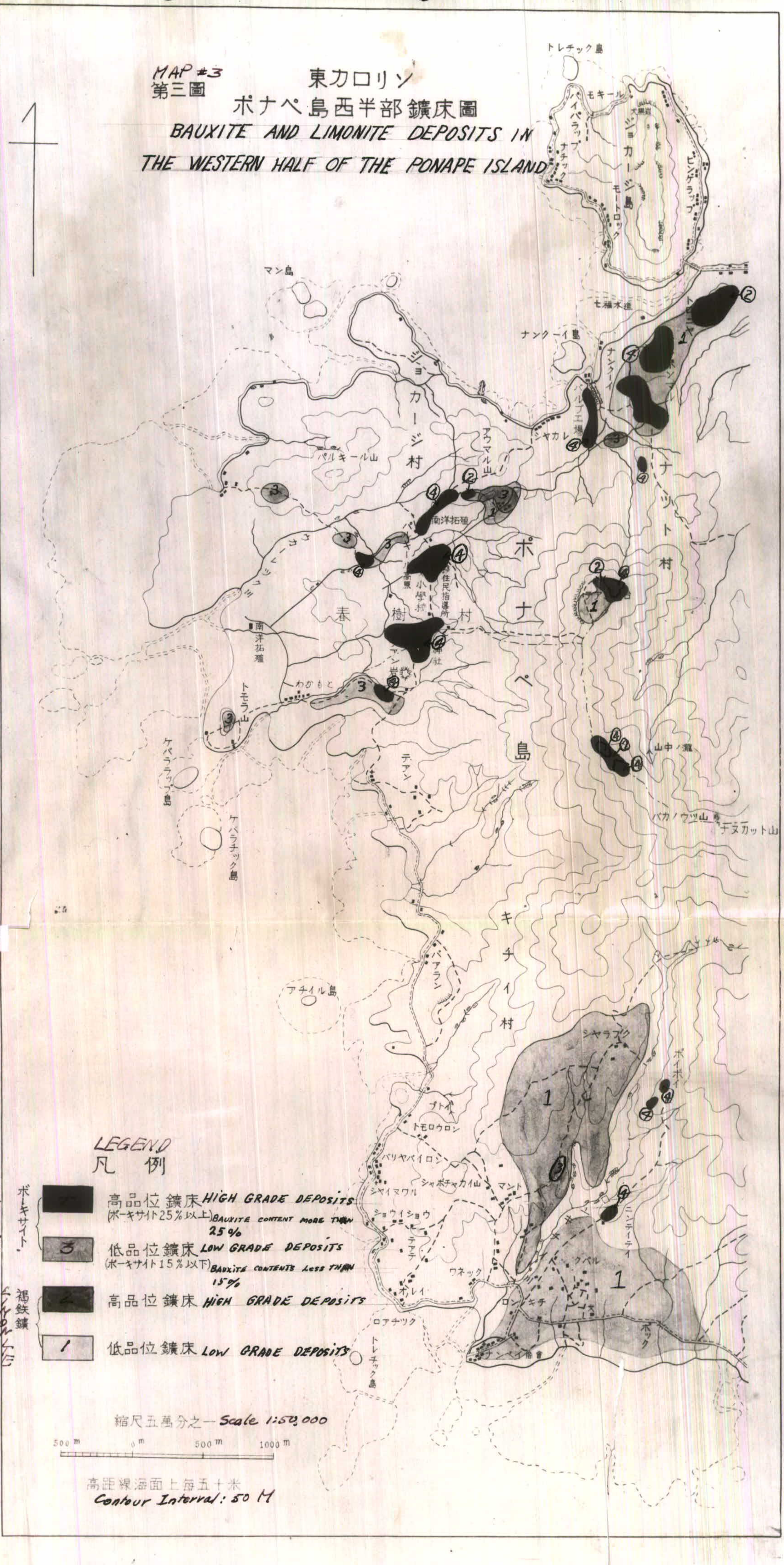
Although the limonite deposit is 7,400,000 metrictons, (of which 400,000 metric tons are high-grade quality), the remaining deposits is not necessarily to be classified as low grade ore, because it is rich in phosphorus (((aid in smelting?))).

Ore Reserve of bauxite is 550,000 Metric tons, and compared to ores of Palau and Bintan, it is high in silica content.

Source rocks for both these deposits are the interbedded alkalic basalt lavas and associated agglomerates. Judging from the topographic and geological studies, Ponape Island is a dissected aspiconide volcano. Northern section of the Kusaie Island is chiefly composed of agglomerate of the above rocks.


第一圖
MAP #1
東カロリン
ポナペ島西半部調査ルート
ITINERARY DURING THE GEOLOGICAL SURVEY
トレチック島
TOLETIC IS.
モキール
ハイパラップ
ナチック
ジョカージ島
JOKAJ IS.
モートロック
ピンゲラップ
マン島
七福水道
トロニヤ
TOLONIA
ナンクーイ島
NANKUI IS.
ナンクーイ
NANKUR
ナンンマル
ヨカージ村
パルキール山
MT. PALIKIR
パルプ工場
シャカレ
SEKERE
アウマル山
PALIKIR PLATEAU
パルキール高原
南洋拓殖
移住民指導所
小學校
春樹村
ナット村
ポナペ島
テアン高台
TEAN PLATEAU
南洋拓殖
TEAN ROCK
テン岩
神社
SHRINE
わかもと
トモラ山
ケパラップ島
ケパラチック島
テアン
TEAN
山中ノ瀧
バカノウツ山
MT. BAKANOTU
ナヌカット山
MT. NANUKAUIAT
キチイ村
KITI
パラン
アチイル島
シャラプク
SHALAPUK
ポイポイ
ブトイ
BUTOI
トモロウロン
パリヤパイロン
シャイヌワル
シャポチャカイ山
マント
ショウイショウ
テアテ
ワネック
オレイ
キチ
ロンキチ
RONKITI
クパル
ロアナック
トレチック島
ナンペイ商會
ポック
SCALE 1/50,000
縮尺五萬分之一
500 m
0 m
500 m
1000 m
高距線海面上每五十米
EACH CONTOUR INTERVAL 50 METERS

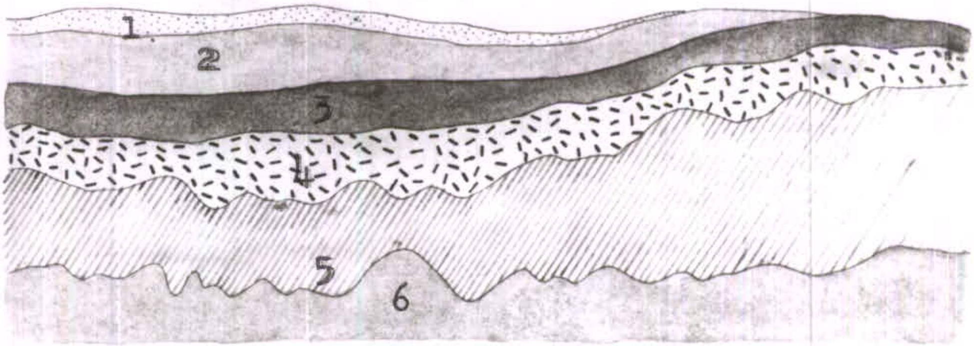

第二圖
MAP No 2
東カロリン
ボナペ島西半部地質圖
GEOLOGICAL MAP OF THE WESTERN HALF OF THE PONAPE IS.
トレチック島
ジョカージ島
マン島
ナンク島
ジョカージ村
パリキール山
ボナペ島
春樹村
トモラ山
ケパララック島
ケパラチック島
アチイル島
キチイ村
山中ノ瀧
ナヌカット山
凡例 LEGENDS
4 准橄欖灰色玄武岩 SEMI OLIVINE (GREY BASALT)
3 輝石橄欖玄武岩類（熔岩ト集塊岩トノ互層）AUGITE OLIVINE BASALTS (ALTERNATION OF LAVA AND AGGLOMERATE)
2 同上（主ニ集塊岩）SAME AS ABOVE (CHIEFLY AGGLOMERATE)
1 エヂル輝石粗面安山岩 AEGIRINE AUGITE TRACHYANDESITE
SCALE 1/50,000
縮尺五萬分之一
500 m 0 m 500 m 1000 m
高距線海面上毎五十米
EACH CONTOUR INTERVAL 50 METERS



MAP #3
第三圖
東カロリン
ポナペ島西半部鑛床圖
BAUXITE AND LIMONITE DEPOSITS IN
THE WESTERN HALF OF THE PONAPE ISLAND
トレチック島
モキール
ジョカージ島
ピンゲラップ
モートロック
七福水道
ナンクーイ島
パルプ工場
シヤカレ
ジョカージ村
パルキール山
アウマル山
南洋拓殖
ナツト村
ポナペ島
春樹村
小學校
住民指導所
神社
南洋拓殖
わかもと
トモラ山
ケバララップ島
ケバラチック島
テアン
山中ノ瀧
パカノウツ山
チヌカット山
マン島
アチイル島
キチイ村
パアラン
シヤラブク
ポイボイ
ナトイ
トモロウロン
バリヤバイロン
シヤボチヤカイ山
マント
シヤイヌワル
ショウイショウ
ワネック
ニンテイテイ
クペル
ロンキチ
ポック
ロアナツク
トレチック島
LEGEND
凡例
BAUXITE
ボーキサイト
高品位鑛床 HIGH GRADE DEPOSITS
(ボーキサイト25%以上) BAUXITE CONTENT MORE THAN 25%
低品位鑛床 LOW GRADE DEPOSITS
(ボーキサイト15%以下) BAUXITE CONTENTS LESS THAN 15%
LIMONITE
褐鉄鑛
高品位鑛床 HIGH GRADE DEPOSITS
低品位鑛床 LOW GRADE DEPOSITS
縮尺五萬分之一 Scale 1:50,000
500 m 0 m 500 m 1000 m
高距線海面上毎五十米
Contour Interval: 50 M

第四圖　ポナペ島鑛床理想斷面圖

MAP 4　IDEAL SECTION OF PONAPE ISLAND DEPOSITS



1　表　土　SIRFACE SOIL

2　褐鐵鑛床　LIMONITE DEPOSIT

3　ボーキサイト鑛床 BAUXITE DEPOSIT

4　ボーキサイトノ結核ニ稍々富ム粘土(カオリン狀土壤)
CLAY (KAOLINIZED) SLIGHTLY RICH IN NODULES OF BAUXITE

5　風化岩石 WEATHERED ROCK

6　基盤岩石(主トシテ玄武岩)　BASE ROCK (CHIEFLY BASALT)

no. 296

SOME NOTES ON PONAPE ISLAND OF THE INNER SOUTH SEAS

By
Shuichi IWAO

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Tokyo, Japan

Contents

Illustrations

[Inserted at end of translation]

SOME NOTES ON PONAPE ISLAND
OF THE INNER SOUTH SEAS

By
Suichi IWAO

Introduction

Forgetting the blazing sun in a cool breeze over flopping palm leaves and bathing in a stream of silvery moonlight on a beach, who can resist a passing feeling of happiness in his heart? Looking up at numberless constellations shining high in the cloudless night sky and gazing absorbedly at the Southern Cross beaming serene light on the southern horizon, who can deny himself a slight nostalgia? There you find sweet poems, and songs full of sorrow, and you see beautiful paintings. That is a moment in an evening on Ponape Island.

Ponape Island is in the eastern part of the East Caroline Islands at long. 158 E, lat. 7 N, and is about 2,000 naut. miles in a straight line from Yokohama. It is the largest island in the South Seas, with an area of about 375 sq. km and is nearly circular in outline, with a circumference of about 25 Ri (100 km). A cargo-passenger boat of the 4,000-5,000-ton class sails nearly every 20 days from Yokohama.

The writer, at the request of the Government General of South Seas, took a three months' trip, in the winter and spring of this year (1940-41) to make a survey of the geology and ore deposits in this region.

A few points that attracted his attention shall be stated here. A number of our geologists have already travelled in the South Seas: Messrs. Otsuki, Hanzawa, Tayama, Tashiro, Nagabuchi, Ishii, Tsubaya, and others. Mr. Tayama was appointed to an office of a "Chief" of the Government General, resident at the Tropical Industry Institute at Palao, and has travelled in all parts of the region. The writer made the return trip in three months, staying at Ponape for less than 40 days, and because of the brevity of the examinations he is afraid that his impressions and observations of the geology and ore deposits may not always be correct. The writer wishes to ask, in advance, that the reader take this into account.

Impressions of Ponape Island

As is usual with other islands of the Inner South Seas, one is surprised at the large number of Japanese inhabitants on Ponape. The Japanese population was 2,398 in 1935 and has increased to about 5,000 during the following 4 or 5 years. In contrast, the native population of 5,800 in 1935 has shown practically no increase in the same period. The reason why the native population does not increase has been studied by many specialists, but it is often the case with many aboriginal tribes. Another thing that attracts travelers' attention is the fact that the natives are too well Japanized. The majority of people, if not in places far from a town, are dressed in nearly the

same clothes as those of the Japanese except for bare feet. The women wear a dress of one piece. The men are clean and always in white shirts which often make them look better than the Japanese. But how does it work? They have parted abruptly with their own customs and have dressed in clothes unsuitable for the climate making them, temporarily, more susceptible to diseases. This is an ironic fact.

A landscape cannot stand by itself. There is history, and we appreciate the landscape only when we view it together with the people who have made the history. Thus the Japanese are increasing more and more while the natives (the majority of them backward Kanakas), suddenly changing their customs, are standing still; the writer cannot but feel that the island's native culture is being destroyed day by day. A forlorn island amid the Pacific Ocean, it was never so peaceful as Tahiti. Does the world's so-called "civilization" never end its encroachment on a single grain upon a great ocean?

There is a detailed and interesting study by Mr. Tadao YANAIBARA (see Bibliography Source 9), on the natives' customs and habits, community, system of land, system of currency, etc.

It may be of interest to state here some characteristics of the natives when we employed them. Each one of the islands in the Inner South Seas is so far apart that originally there was practically no communication between natives of different islands (though there were a few exceptions), and as a result the natives of each island have their own customs and language.

Indolence of the Natives

We spent about a week in the survey on Kusaie Island before going to Ponape. The natives here were very obedient and meek, and though slow, they worked without complaints. Even when wet by the rain from morning till evening, they worked smiling. The chief came out to pay us his respect. Is that because there are still fewer Japanese there? Contrary to this, we were put out at the natives in Ponape. They may be sympathized with because we made them work under compulsion, those who, having been blessed with natural resources and sunshine for hundred of years, have not had to work hard. Anyway, in indolence and craftiness, they are second to none. Their efficiency is less than one-third of that of the Japanese. Although they are quick in climbing rocks, skilled in fording streams, they intentionally walk slowly and loiter on their way whenever they can. They are almost spiteful as they are slow in going but quick in returning. Starting with 8 coolies on the first day there are 6 on the next and 5 on the third and so on until one half are gone in about 4 days. Scare them by saying they will be thrown into jail, and all of them come the next day, but it is of no use on the second day. It is no use to have an official of the Government General frighten them. They dread nothing but a policeman. The shortage of labor is felt year by year just as in Japan, so even such lazy natives make themselves useful, aggravating their own weak point. They are basically simple and innocent, and if you treat them kindly,

they soon become too familiar with you. Natives on Kusaie, and those on this island until several years ago, brought breadfruit for their lunch, but nowadays some of them will not work unless you give them rice which is difficult even for the Japanese to get. Still a worse fellow, though he has always walked barefoot, wants a pair of rubber "tabi" (shoes) to our astonishment. Japanese themselves have unwittingly taught them to behave in this way. A matter for congratulation, or for regret, the writer does not know.

Japanese and Ponape Languages

In the 20 years since the South Sea Islands became our Mandated Territory, Japanese culture has reached the far corners of the islands and the natives have learned the Japanese language and history. Half of the native men in their twenties and thirties, as well as the students in public schools (where native children are educated) speak Japanese. They are always in contact with Japanese and some of them are quite fluent in conversation. On the other hand, Japanese who understand the Ponape language are very rare. Superficially it seems unnecessary for the Japanese to learn the language but there are really important reasons for doing so. The Japanese keep the natives in service without understanding what they say, but the natives are at work knowing all that the Japanese say.

In Ponape, and in many other islands, are a number of Catholic churches. The most stately looking building in each of the towns or

villages is usually the church. The ministers are usually Spanish and most of them understand the Ponape language and translate the Bible into it and preach the gospel to natives. This is also true of the American ministers on Kusaie Island. The natives are strongly influenced by the ministers and they refuse to work on Sunday, no matter how high the pay may be. They go to church in their fine dress and it is a pleasant day for them. People, old and young, go a long distance chatting cheerfully. The writer keenly feels that the matter calls for our reflection. The native language should not be thought of lightly, and it is necessary to think how well we can educate these islanders. Maybe it was due to the necessity of translating the Bible into the Ponape language that natives were taught to write Roman letters and as a result they understand Roman spelling of the Ponape language.

Henry Nampei

Upon the shore of the Ronkiti River, Kiti Village on the west coast, where coconuts ripen and mango trees grow thick, there stands a bronze statue glaring at the vast expanse of the Pacific Ocean. It is a dignified gentleman in a frockcoat, with pink flowers on the green in front and a neat-looking church building in the back. This is the hero of Ponape natives, the late Henry Nampei. He was the son of a German father and a native mother (succession by female line among the natives) and being quite ambitious while young, he maintained a successful coconut plantation, became a millionaire and went to Europe.

After returning home, Henry Nampei did a great deal for the welfare of the natives, contributed much to the Japanese administration of the islands and was rewarded by the government. His son, Oliver Nampei has succeeded his father and now operates the coconut plantation, employing Japanese. He must be the hope of the natives.

Ponape Island and Mining Engineers

Mining engineers on the staff of the Government General of South Seas are too few in number. The number would be sufficient if there were good transportation facilities as in Japan. With exception of Palao, there are practically no mining engineers resident on the islands. The writer feels that even a resident assistant in each Branch Office who understands common minerals would help a great deal in geological and prospecting work and in giving preliminary information about minerals on that island.

Geomorphology of Ponape Island

The geomorphology of the island, if shown by a detailed topographical map, a cross section and a simple sketch, would be clear at a glance. At the present time, however, the writer is not permitted to publish these and has substituted an idealized cross section and its description (Fig. 2).

Around the island, about 2 to 4 naut. miles off the coast, are located barrier reefs, parts of which are connected with shore reefs.

A zone of mangrove forest several hundred to 4,000 meters wide occupies the inner or coastal side of the shore reef and further inland on the gentle slope of the island shore is a zone of coconut forest. The coconut trees thin out and disappear as the land surface increases its altitude from the sea-shore into the central mountains where miscellaneous trees grow. The mountains attain a maximum altitude of 750 m. above the sea at Mt. Nanalaut, which, alined with other mountains of nearly equal height, is located at the center of the island, with its flanks descending seaward in a gentle slope. When viewed from a distance, Mt. Nanalaut looks like a truncated cone. As one travels closer, however, he finds that it is built of fairly well dissected beds of volcanic rocks showing remnants of the plane surface of lava flows. The island evidently is a dissected volcanic island. In going upstream one often finds outcrops along valley walls of thick lavas or agglomerate, as is usual in a volcanic area. Waterfalls 20-30 m. high are common, and one along the Ronkiti River at Kichi Village reaches the height of 70 m. The amount of the river water is not abundant except in rainy seasons when the flood waters are torrential and are said to occasionally carry away men and horses. The crests of the mountains, even in dry season, are covered with clouds and rarely can be seen; this is caused by an ascending current of air which brings moist air from the ocean to the summit.

Geology and Lithology

General geology and rock types. The writer traversed only the western half of the island, from Jokaj to Kichi and, therefore, cannot make a generalization on the geology of the whole island from personal observation. The outline of the geology as given below has been derived from a study of papers by Messrs. Otsuki, Yoshii and Kinoshita, and others.

As has already been stated, the island is a dissected volcanic island. The bulk of the island consists in an alternation of lavas and agglomerates of basalts, with either one or the other prevailing at different places. Everywhere on the island bedding planes are easily observed, and the thickness of lava flows and agglomerate beds vary from 10 to 40 m. The agglomerates are often pierced with basalt dykes and contorted in places but the general dip of the bedding planes is very gentle suggesting the original form of the island to have been an aspiconide. It is of great interest if we think of the basic nature of the rocks.

According to previous literature the rocks and their localities are as follows:

Rocks	Localities
1) Olivine-augite-andesite	Greater part of the island
2) Gray nepheline-basalt	Langar, I. Colonia, and Mant Is.
3) Olivine-augite [fels?]	Water fall at Nankui
4) Picrite	Nanukapkap

Rocks	Localities
5) Olivine-basalt	Jokaj, Triangle (Sankaku) Mountain & Matalanim
6) Basanitoid	Matalanim castle wall
7) Magma-basalt	Colonia
8) Dolerite	Natto peninsula
9) Olivine-dolerite	Jokaj
10) Gray analcime-basalt	Langar
11) Aegirine-trachyte	Mt. Tamaei, Takaei Island
12) Porphyrite	Wone, middle of Roi Rock
13) Trachyte	Wone, middle of Roi Rock
14) Analcime-trachyte	Langar Island
15) Barkevikite-basalt	Iftok
16) Olivine-augite-lamprophyre	Wone, Top of Roi Rock
17) Monchiquite	Kichi, East end of Tamon

The writer made his observations in a limited time and could not make sure of the interrelation of these rocks, but so far as the western half of the Ponape Island is concerned, the rocks seem to be divided into the following three groups (Fig. 3).

1) Olivine-augite-basalt group

2) Pacificite group (Basanitoid?)

3) Aegirine-trachyandesite group

The above-listed 17 kinds of rocks may be grouped into these three types. In other words, only different portions of one lava or difference

in crystallinity in different beds of lavas may have caused so many types of rocks. At least a part of what was called a gray nepheline-basalt, it is suspected, belongs to the pacificite group with anemousite.

A description of photomicrographs representative of the three types of rocks is as follows: (See Figs. 4, 5, 6).

1) Olivine-augite-basalt. Dark greenish-gray, compact rock with indistinct fluidal structure.

Phenocrysts:
- Olivine 0.5 mm. ±
- Augite 1.5 mm. ±, distinctly zonally built, central part nearly colorless, peripheral parts purplish, yellowish green (titaniferous)

Groundmass: Holocrystalline, consist chiefly of pyroxenes and feldspars, some magnetite, and a small amount of apatite.
- <u>Augite</u> Nearly the same as the peripheral portion of phenocryst augite (titaniferous).
- Plagioclase 0.3 mm. ± long. Long prismatic, distinctly zonally built. Interstices filled with alkali feldspars?

2) Pacificite. Dark grayish blue-green, hard, compact rock. The sample at Tean plateau which the writer collected was eroded along vertical joints into queer-looking rocks resembling Karren on a limestone plateau. When struck with a hammer, these rocks sound like sanukite, or have a metallic sound.

Phenocrysts:	(Olivine	1 mm. in longer diameter
	(Augite	1-1.5 mm. in diameter, distinctly zonally built, central part light green periphery dirty yellowish green.

Groundmass: Holocrystalline, equigranular, consisting mainly of augite, anemousite and small amounts of a light-purplish mineral and magnetite, with very small amounts of apatite.

Augite. The same as the marginal portion of the phenocryst.

Anemousite? Colorless, refractive indices nearly equal to that of balsam. Birefringence about equal to potash feldspars, granular, appears to be slightly zonal.

A light-purplish mineral. Dirty light purple, granular. Birefringence very low. Refractive indices about equal to potash feldspar.

3) Aegirine-trachyandesite. Collected by the writer. The sample described here is from the midstream of the Ronkiti River. Light grayish purple-brown, more or less porous rock. Greasy luster under a direct ray of light.

Phenocrysts: Occasionally feldspars

Groundmass: With trachytic (fluidal) structure, consisting mainly of plagioclase, potash feldspar, aegirine, and magnetite, with small amounts of apatite. Plagioclase encircles, as a mantle, long prisms of potash feldspar. Aegirine is of deep golden color possibly due to slight alteration.

All of these rocks are of utmost interest, and should never be overlooked in the study of volcanoes in the Pacific. Chemical analyses of these three rocks are now under way by Hiratsuka, "Chief" of the Geological Survey. The writer looks forward to the opportunity to publish rock descriptions together with the chemical analyses. The readers are requested to excuse the rough sketch in this paper.

Mineral deposits. In the past, attention was paid only to phosphate in the South Seas, but recently quite a few kinds of minerals are being worked there.

Phosphate:	Ebon, Angaur, Pelilien, (Peleliu)*, Fais, Tokobay, (Tobi), Sonsorol, Rota.
Bauxite:	Ponape, Palao (Palau)*
Lignite:	Palao
Zinc:	Palao
Manganese:	Palao, Saipan
Nickel:	Yap
Copper:	Yap
Gold:	Ponape, Palao

Acid earth: Saipan

Limestone: Palao

Fire clay: Palao

Etc.

Now, how about Ponape Island? Beside the so-called bog iron ore and pyrite which was reported by Mr. Otsuki (Bibliography, Source 1), bauxite is known to be distributed in pretty large areas all over the island, either together with or independently from the limonite. The bauxite deposits are supposed to have been studied in detail by Messrs. Tashiro and Nagabuchi and the iron ore deposits, too, are supposed to have been surveyed by people from some other quarters. The writer wishes to describe, briefly, what can be published.

Both the limonite and the bauxite are residual deposits that cover the surface of the basaltic rock, so they are distributed only upon flat places but quite independent of altitude. That is, they exist only where the erosion by rain water is not too strong. The vertical distribution shows a definite sequence of minerals, in descending order: surface debris, iron ores, bauxite, kaolinitic soil, weathered rock, basalt. Each one of these varies widely in its degree of development, and some sequences may be lacking in one or more of the minerals; as a

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* Names in parentheses are National Geographic spellings.

result, some portions of deposits have bauxite only, and others have limonite only. This is shown in the idealized cross section in Fig. 7. This phenomenon has been noted in Bintan Island, Dutch East Indies, too, and is supposed to be characteristic of such a residual ore deposit. The upper portion of the kaolinitic soil contain nodular, often spongy bauxite masses. Bauxite often fills in fissures of weathered rocks and accumulates around grass roots and tree roots. Ores with a composition intermediate between bauxite and limonite are often met with.

What Mr. Otsuki once described as a bog iron ore is no doubt the residual limonite and redeposited (in situ) limonite deposit. The writer cannot freely discuss the actual case in each locality but he would like to show here a few analyses of bauxite and limonite for the reader's information. Samples were washed before the analysis.

	Fe	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	MnO	CaO	P_2O_5	$+H_2O$	S	Sp.gr
Iron Ore	35.41	50.63	23.30	2.22	0.80	0.49	0.01	0.37	21.70		2.70
	40.56										
	47.51		12.31	5.28							
	39.44										
	49.97		4.82	10.82							3.56
	35.99			2.66	2.07	0.09		P-0.34		0.04	
	42.20			5.81	1.79	0.11		P-0.66		0.02	
	46.73										
	36.31										

(Chart continued)

	Fe	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	MnO	CaO	P_2O_5	$+H_2O$	S	Sp.gr
Bauxite		25.20	33.80	11.40	0.55				27.84		2.18
			59.59	5.15							
			59.92	4.50							
		51.01	22.69	5.70							
		27.89	42.56	1.85							
		19.96	47.89	3.50							
		18.04	51.36	2.10							
			57.69	3.10							
			53.63	3.95							

From these analyses it can be seen that the limonite is not of high grade. The phosphorous content is fairly high and the ore also contains aluminous clay-like matter. The bauxite ore contains almost as much aluminum as those ores in Bintan and Palao Islands, but is a little higher in silica, and also contains a higher percentage of iron. The content of titanium oxide, although only one sample was analysed, is not high. This bauxite is of a gibbsite type, like that in Bintan Island. The iron pyrite, according to Mr. Otsuki, forms a vein in the basalt near Nanukapkap, containing a trace of copper but no gold or silver. Although the writer had no chance to visit it, it does not seem to amount to very much.

The gold ore comes from a gold-quartz vein in supposed dolerite on Triangle mountain. The ore is now worked by a certain firm but the scale of the vein is not yet known. The writer had no chance to visit this deposit.

The writer had anticipated the landscape of the South Seas to be very pretty but on his departure occasionally came across scenes contrary to his expectation. Be it as it may, the South Seas Islands are beautiful. The Emerald Sea, the deep green coconut trees, the stream of moonlight, the sweet fragrance of lemon grass, the native chorus in harmony with a guitar, all is sure to remain deeply impressed in his mind.

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In the writer's present study, he is indebted to Messrs. Ishii, Tashiro, Nagabuchi, and Imai and other gentlemen for their kind advice. The writer wants to take this opportunity to express his gratitude to these gentlemen.

Figure 1. List of a few Ponape words as written by a native [Not reproduced in this translation].

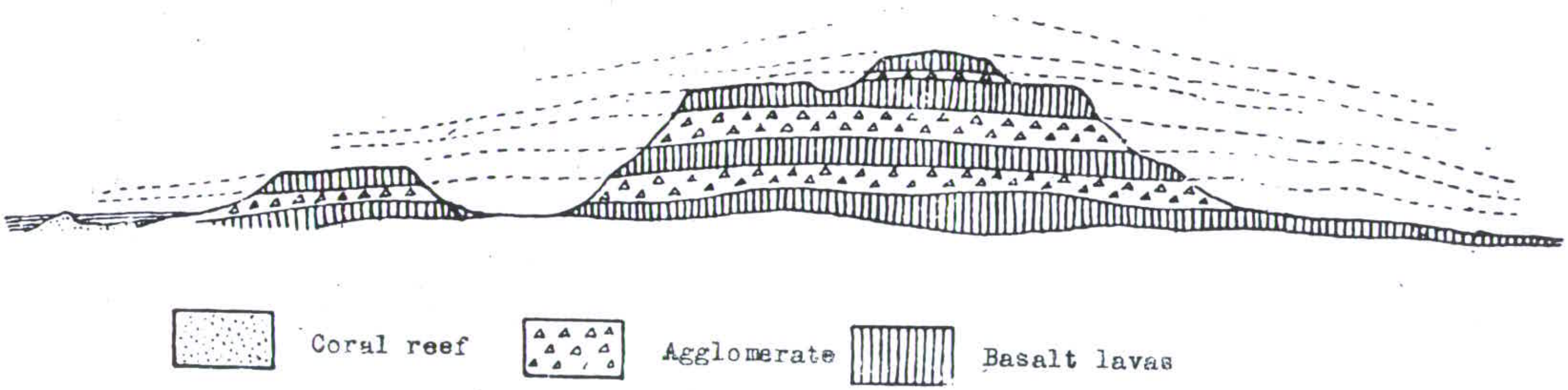

Figure 2. Idealized cross section of Ponape Island. As actual topography cannot be shown, vertical and horizontal scales are modified only to show the relation of geology and geomorphology.

Basalts (Alternation of lavas and agglomerates)

Gray nepheline-basalt or pacificite?

Area in which agglomerates prevail

Aegirine-trachyandesite (the lowest)

Figure 3. Geologic sketch map of Ponape Island

Coast line is from the report by Mr. Otsuki. Coral reefs have been omitted.

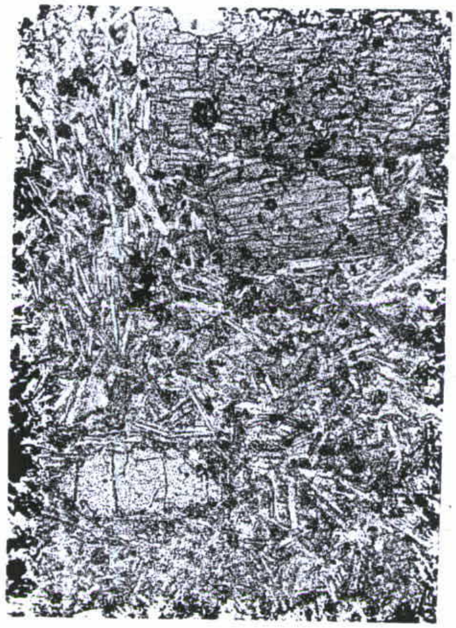

Figure 4. Olivine-augite-basalt. Note the zonal structure of the augite.

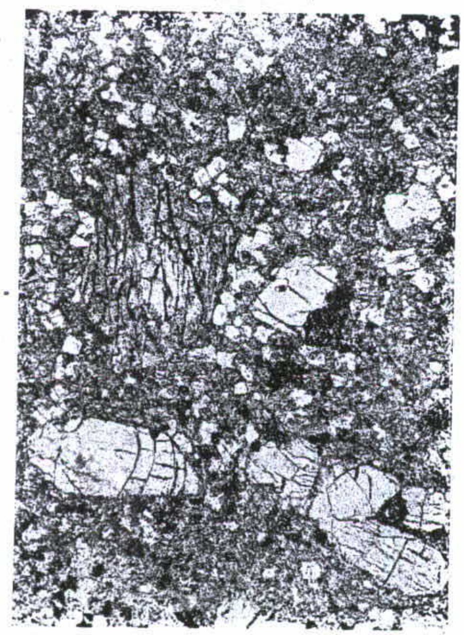

Figure 5. Pacificite. Note the zonal structure of augite and the shape of colorless minerals in the groundmass.

Figure 6. Aegirine-trachyandesite.

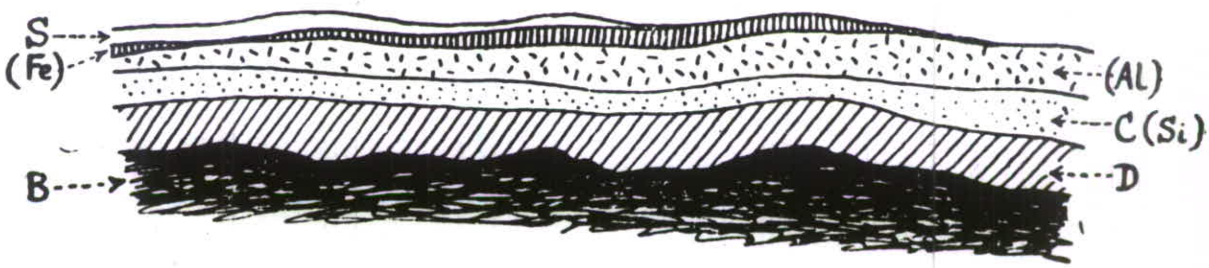

Figure 7. Idealized cross section of the bauxite and limonite deposit.

S	Surface debris	D	Weathered rock
(Fe)	Limonite	B	Basalt
(Al)	Bauxite	C(Si)	Kaolinitic soil

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VOLCANIC ROCKS OF THE CHICHI JIMA GROUP

By
Toshi SUZUKI

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Translator's Note

This article was written 68 years ago. Accordingly, the technical terms used in this article are quite different from those of the present day. Moreover, the descriptions are rather ambiguous. Therefore, though I translated this article with the best attention, I am too diffident to state positively that this translation is free from mistakes.

Volcanic Rocks of the Chichi Jima Group

By
Toshi SUZUKI

The Chichi Jima Group is the main part of the Ogasawara Islands. This island-group consists of volcanic and volcanic detrital rocks except Tertiary (?) Foraminifera-bearing limestone and coral conglomerate, the latter of which is the recent beach deposit. It is evident from the geological structure that this island-group is an extinct volcano which repeated frequently violent activity in the past. Microscopically examined, there are the following four kinds of rocks.

1. Augite andesite
2. Augite andesite glass
3. Quartz augite andesite
4. Basalt

The description of the above rocks will be given below.

1. Augite andesite. This is the most common volcanic rock in Japan, and it is of wide occurrence in volcanic areas. In the Chichi Jima Group this rock occurs here and there. However, the rock in this island-group is a little different from that of Japan proper. Generally speaking, the latter is poor in glass, and the phenocrysts are microcrystalline, while in the former, glass is found in the groundmass without exception, and the phenocrysts are rarely microcrystalline.

The phenocrysts of augite andesite in the Chichi Jima Group sometimes are large, and sometimes are so small that they are invisible

with the naked eye. The groundmass is compact, and mostly blackish or dark green in color. Though this rock resembles apparently to diabase and trachyte, this is a volcanic rock extruded after the Tertiary period. This rock is made up of plagioclase, augite, and magnetite. Those minerals are interspersed in the more or less glassy groundmass. Therefore, it is beyond question that this rock is augite andesite. The essential and accessory constituents of this rock as well as the nature of groundmass will be described below.

Plagioclase. The crystal of plagioclase is rectangular in form and small in size. Even large crystal is 2.5 millimeters in diameter. Usually the crystal is of albite twin. It is transparent like glass and frequently zonal structure is exhibited. Though the twinning planes are distinct, sometimes the lines do not extend through the entire body of crystal. Sometimes the lines become indistinct midway. Sometimes fine lines are visible only on the margin of crystal. Sometimes the lines pass through the brachydiagonal plane, or sometimes they are zonalled. Such being the case, it is beyond question that the crystal is plagioclase. The inclusions are abundant, but the kinds are very few. In most cases the inclusions are glass or gas-pores. Though the form and the arrangement of plagioclase crystals are varied, it is conspicuous that they are arranged in the spherical form in the direction of the twinning planes.

Sanidine. The crystal of this mineral which is of elongated prism or ill-defined is rarely interspersed through the groundmass. The crystal is glassy as well as clear, and single or twinned. The

crystal is frequently twinned according to the Carlsbad Law. There are few which present zoning. The inclusions are the same as those of plagioclase.

Augite. The size of crystal of this mineral is varied. Some crystals are ill-defined, and sometimes the crystals are well-defined, being aggregates of monoclinic prism orthopinacoid and clinopinacoid. Sometimes they are devoid of monoclinic prism and exhibit pinacoid. Sometimes they exhibit conspicuous monoclinic pyramid. The crystals, isolated or in cluster are mixed in the groundmass. The slide of this mineral is transparent, and of yellowish-brown or light green in color and rarely colorless. The axial color is present, though its degree is varied. Some are not frequently twinned. In many cases the twinning plane is parallel to the orthopinacoid. Rarely the twinning plane is a transformation of orthopinacoid. The twin frequently forms a twinning plane like that of plagioclase. Under polarized light, frequently rainbow-colored twinning plane is exhibited. The parallel growth of crystals may probably be ascribed to gradual solidification and crystallization. The inclusions are not abundant, and consist of glass, gas-pores, and magnetite. In many cases, glass is spherical with a fixed bubble in the center. Magnetite is granular, and usually occurs in augite.

Magnetite. This mineral usually is found in augite andesite. It is sure that magnetite is the essential constituent of augite andesite. There are few which show well-defined crystal, and most of them are granular.

Apatite. Usually more or less apatite is contained in andesite. However, in the augite andesite collected in Chichi Jima this mineral was not detected.

Chalcedony. This mineral fills pores or fissures of the rock. It is colorless or of light blue. This is found most abundantly in the augite andesite of Otōto Jima. Under polarized light, aggregate of spherulites arranged in a radial way presents beautiful rainbow colors.

Tridymite. This mineral is found in one of the specimens collected by the writer. This mineral fills up the space of groundmass. Some of the crystals are indistinct, and well-defined crystals are arranged just like house-tiles on the roof. The crystals are colorless and transparent. Under polarized light, the color changes from colorless to light bluish dark color.

Groundmass. Generally the groundmass has more or less glass, and few are microcrystalline. The glass is colorless or brownish, and that which suffered changes is opaque. Usually a large quantity of feldspar, augite, and grains of magnetite are mixed. Feldspar crystallizes mostly in the triclinic system, the crystal is prismatic, and sometimes both the ends of the crystal are fissured. The crystal is single or twinned, and presents glassy luster. Augite is colorless or of light green, and consists of grains or microlites. Magnetite exhibits rarely well-defined crystal.

The nature of augite andesite of the Chichi Jima Group is as stated above. The characteristics of a few samples of augite andesite collected by the writer will be described in detail. Augite andesite exposed

at Kominato is of dark color with minute phenocrysts, and round pores are filled up with white siliceous mud. Microscopically examined, crystals of plagioclase and augite as well as magnetite grains are scattered through the groundmass.

Plagioclase is small in quantity and clear as glass. Some of this mineral are in cluster, and some are isolated. The edge of crystal is rounded, and is fissured here and there. This mineral forms rarely well-defined crystal. This may be probably ascribed to the changes suffered when the rock was fluid with high temperature. The crystal has few inclusion, and glass as well as gas-pores are found scattered. Well-defined crystals of augite are in aggregate, and few are fissured. The crystal is mostly monoclinic prism orthopinacoid, clinopinacoid, or aggregate of clinopinacoid. Sometimes the crystal has a perfect pinacoid. The face obtained by cutting it off at right angles to the principal axis is always octagonal, and the cleavage lines meet at an angle of about 87° each other. The slide is colorless or of yellowish brown. The axial color is present, though faintly. Few are twinned, and a few faces which are cut at almost right angle to the principal axis, under polarized light, present purplish brown and yellowish brown colors, and the two colors are parallel to the external side of crystal. The colors parallel to the external side of crystal may probably show the growth lines due to successive crystallization.

The inclusions are of a small quantity, and is composed of glass, gas-pores, and magnetite grains.

The groundmass is composed of feldspar, augite, magnetite grains, and microlites. The space is filled up with glass. The microlites are very abundant, and all of them are glassy. There are two kinds of microlites. One is spheroidal, presents brown color, and is found aggregated here and there. The other is colorless, transparent, is found in cluster, and looks like a fern-leaf. Besides these, there are indistinct microlites. Acicular crystals which are connected look like a bamboo blind. The form resembles to an acicular crystal of hornblende.

The augite andesite in the eastern corner of Oomura is black and compact. Augite and glassy feldspar form a rather large crystal, and the crystals are interspersed in the groundmass. Microscopically examined, the groundmass consists of opaque glass which is spherical, and microlites of augite and feldspar as well as magnetite grains are scattered in the groundmass.

The phenocrysts are composed of feldspar and augite. There are some sanidine, but most of them are plagioclase. The plagioclase is of elongated prism. The twinning line is rarely fractured, and sometimes presents zonal structure. Of the inclusions, glass is abundant. The glass is arranged in the direction of macro-axis of crystal, and its color is coffee-brown. The form is irregular and many are arranged in a ropy way.

The augite is brownish yellow or light green. Its crystal is ill- or well-defined. The axial color is marked. Sometimes the crystal is twinned. The inclusions are composed of glass spherules and magnetite grains.

Of the augite andesite collected in the vicinity of Oogiura, there are some which contain tridymite. Crystals of feldspar and augite are interspersed in the groundmass of light bluish dark color. This rock looks to be loose, and resembles to trachyte. However, microscopically examined, the feldspar is in the triclinic crystal system, and there is no orthclase. Therefore, it is beyond question that the rock is not trachyte. The groundmass is rather microcrystalline, and is composed of feldspar, augite, magnetite grains as well as feldspar-like substance. In the space of groundmass, gromeroblasmatic of tridymite is found. The property of these minerals was described above.

The augite andesite exposed on the cliff of Kurose in Otōto Jima is of blackish green, compact, and rather microcrystalline. The appearance resembles to diabase. In the goundmass a green alteration product only is scattered. The fissures of this rock are filled up with chalcedony. Frequently the weathered surface of this rock being smooth, presents greasy luster, and has altered into serpentine. Microscopically examined, plagioclase, augite, and magnetite grains are interspersed in the groundmass.

Plagioclase is small in quantity and its crystal is well-defined. All crystals have more or less twinning lines. Augite is rather large in quantity. Its crystal is well- or ill-defined. Some of the crystals are twinned. The axial color is marked. The crystal is colorless and rich in crack. Frequently the crystal has altered into other mineral. Sometimes the crystal keeps its original form and has altered into serpentine. This may probably have originated from olivine. The groundmass

is composed of phenocritic minerals, and a small quantity of glass as well as alteration product are mixed. The pores are filled up with chalcedony. The chalcedony which is on the inside of the pores is spherical in form and colorless. The rest is brown in color.

2. Augite andesite glass. This rock is exposed in many places in the Chichi Jima Group and always is found in the upper part of volcanic rocks. Particularly this rock is exposed in the area around the crater of Futami harbor. The appearance closely resembles to pitchstone. This rock is compact and sometimes porous. Frequently pores extend in the direction of the texture of the rock, and the pores are filled up with white siliceous substance. A newly made fracture is lustrous black or pitch-black in color. When it is exposed in the air, a thin blackish-blue film is produced on the surface of fracture. This rock presents glassy or sometimes greasy luster. The variety which presents glassy luster is rather fragile and is composed of round granules. This variety presents perlitic structure. The fracture of the variety which presents greasy luster is mostly conchoidal. This rock is strongly magnetic. When a piece of this rock is heated with a blowpipe, it is fused easily and becomes an opaque black ball. This rock is not easily dissolved in hydrochloric acid.

As described above, the macroscopic property of this rock closely resembles to trachylite. However, microscopically examined, it is evident that this is not trachylite, as microlites of plagioclase, augite, and magnetite are interspersed in the groundmass, but olivine is wanting.

The augite andesite glass exposed in a place between Oogiura and Kita-fukurozawa is black in color and rich in pores which are filled up with siliceous substance. When a slide of this rock is microscopically examined, it is found that the essential constituents of augite andesite, namely plagioclase, augite, and magnetite, are interspersed in the groundmass.

The plagioclase is glassy and prismatic. More or less twinning lines are present. The inclusions are glassy and abundant. The inclusions are scattered in the direction of the twinning lines. The property of inclusions resembles to the glass of the groundmass, and they are blackish brown in color. The form is irregular. Generally the size and quantity of inclusions are in proportion to the size of crystal.

The augite is yellowish green in color, and some of the mineral form well-defined crystal. Orthopinacoid, clinopinacoid, and clinoprism are the crystal forms which are frequently met with. The axial color is exhibited, and the mineral is rarely twinned. The crystal is frequently fissured. The inclusions are composed of colorless glass spherulites and magnetite grains. Sometimes feldspar including brown glass is found in the inclusion. The glass spherulites included in the augite seems to be different from those in the groundmass.

The size of magnetite is varied. The crystal of small one is rather well-defined, and presents tetrahedron or hexahedron.

The groundmass is composed of blackish-brown glass, and feldspar, augite, as well as magnetite grains, present flow structure or perlitic structure. The feldspar generally belongs to the triclinic system and

is single or twinned. The crystal form is prismatic or rarely rhombic, and resembles to the feldspar scattered in the glassy groundmass of the lava of Vesuvius.

The augite andesite glass collected on the slope of Maru Yama is compact and pitch-black with white speckles. The fracture is conchoidal. The plagioclase scattered in the groundmass is prismatic or irregular in form, and abundant groundmass glass is included. The crystal has well-defined twinning lines, though the crystal is fissured.

The crystal of the augite is ill-defined and light green in color. The crystal is fissured and contains abundant magnetite and glass spherulites. The groundmass is composed of glass, and feldspar, augite as well as magnetite grains are mixed abundantly. The arrangement of the constituents presents flow structure and sometimes perlitic structure. In the groundmass there are pores, which are filled up with ill-defined siliceous substance. The color of the siliceous substance is white or light brown.

At Kita-fukurozawa black, compact augite andesite glass is exposed in layers. Irregular pores extend in the direction of the lava-flow, and the pores are filled up with siliceous substance. Microscopically examined, besides the essential constituents, a small quantity of sanidine is found scattered in the groundmass. Of the essential constituents, plagioclase is most abundant. The plagioclase is prismatic in form, clear, and poorly fissured. The glassy inclusions are arranged in the direction of the twinning line or scattered in disorder. The

color of the glassy inclusions is coffee brown. Besides the glassy inclusions, phenocrystic minerals and augite grains are included.

The sanidine is transparent and prismatic in form. The inclusions of this mineral are the same as those of plagioclase. The augite is of light green or yellowish brown in color. The crystal is in aggregation or single. The well-defined crystal presents orthopinacoid, clinopinacoid, or monoclinic prism. Sometimes the crystal is monoclinic pyramid. A marked cleavage line exhibits itself on the face made by cutting the crystal off at right angles to the main axis. The axial color is marked. Glass spherulites and magnetite grains are included. Sometimes large crystals of magnetite are included. Though the crystal is mostly ill-defined, it is rarely tetrahedron.

The groundmass is composed of coffee-brown glass, feldspar, acicular augite, and abundant magnetite grains are mixed.

The greenish black obsidian from Kurose in Otōto Jima will be mentioned below. Microscopically examined, the obsidian is composed of transparent glass of light green. The glass is fissured. The microlites found in the groundmass are the same as those found in augite andesite, namely plagioclase, augite, and a small quantity of magnetite grains. For the above reason, the writer includes the obsidian into the augite andesite. The plagioclase is generally prismatic, glassy, and transparent. In the plagioclase peculiar glassy inclusions are found. Large ones of the crystals present zonal structure, and they are found in aggression, and the crystals are always surrounded by brownish black mimetic crystals. The twinning line exists, though sometimes it is

indistinct. This shows that the mineral is not orthoclase. The augite is colorless or of light green. The mineral forms a well-defined crystal in some cases, but lacks monoclinic pyramidal face. Some of the crystals are twinned. The twinning plane is mainly parallel to the orthopinacoid. The axial color is rather marked. As is the case of plagioclase, the crystals are surrounded by blackish-brown mimetic crystals. The inclusions are glass. In regard to magnetite, there is nothing to be described.

3. Quartz augite andesite. This rock composes the skeleton of the Chichi Jima Group. The content of augite is very small in every variety of this rock. The rock collected in the vicinity of Asahi Yama will be described below.

This rock is of light dark green in color, and rather porous. The pores are filled up with green mud. The phenocrysts scattered in the groundmass are feldspar, augite, quartz, and magnetite. The augite is small in quantity, black in color, and takes a long prismatic form. The quartz is rather abundant. The larger one is 3.5 millimeters in diameter. The edges of crystal are rounded.

When examined with a microscope, most of feldspar phenocrysts present twinning line. So it is sure that the mineral is plagioclase. The rest of phenocrysts are the composition plane of basal pinacoid and a small quantity of sanidine. The tridymite is transparent, the edges are rather rounded, and the mineral is twinned according to the Carlsbad law. A large quantity of glass is included. The glass is

brown in color, and a fixed bubble is contained in each glass. Sometimes an acicular crystal is attached to the glass. A small quantity of magnetite grains also is contained in the glass.

The sanidine is glassy, and transparent. Acicular crystals sometimes are included. The augite which is green or yellowish green in color and prismatic in form is rarely scattered. The axial color is marked. The crystal is fissured and ill-defined.

In a thin slide there is very few quartz crystal such as seen in a specimen, probably because the crystal is highly fissured and large crystal is destroyed when the rock is ground. The edges of the crystal are rounded and distinct. The crystal includes glass and acicular crystals. There are few which include fixed bubbles. Abundant magnetite is scattered. Some of them form tetrahedron, but most of them are granular.

The groundmass is composed of feldspar, chlorite, magnetite grains, and metamorphic glass. Feldspar crystallizes in the triclinic system, and is twinned or single. The crystal form is prismatic, and both the ends of the crystal are fractured into the form of tussel. Green mud which fills up the space of the groundmass seems to be epigenetic.

4. Basalt. The basalt closely resembles to augite andesite in property and mostly occurs in the localities where the latter occurs. Therefore, it is difficult to ascertain the mode of extrusion. The mode of extrusion of this rock can be observed in the basalt exposed on the Hatsuse Gawa. The basalt extruded through the augite andesite.

The extrusion seems to have occured after the augite andesite was solidified. The basalt is black in color, and small phenocrysts are scattered. There are round cavities which are filled up with siliceous substance. When examined with a microscope, it is found that the nature of the rock slightly resembles to that of the augite andesite at Kominato. The only difference is that the basalt is devoid of olivine. There are few fresh olivine, and it is not rare that olivine has altered into iron-oxidic substance. The above-mentioned four kinds of rocks, namely augite andesite, augite andesite glass, quartz augite andesite, and basalt, are different in property. It is true. However, it cannot be said that those rocks are quite different one another. If glass is contained abundantly in the groundmass of augite andesite, the rock alters into augite andesite glass; if quartz augite andesite loses quartz, the rock alters into augite andesite; and if olivine is not contained in basalt, the rock alters into augite andesite. Moreover, there are intermediate ones which rank between two varieties. The alteration of rocks as seen in the Chichi Jima Group may be a quite natural phenomenon in nature.

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GLACIAL TOPOGRAPHY

from

CHAPTER 11, TOPOGRAPHY OF JAPAN

By

Dr. T. Tujimura

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Glacial Topography*

by

Dr. T. Tujimura

The strong relief mountains of the Hida, Kiso, and Akaishi Mountains ranging along the eastern boundary of South Japan, though of small scale, show an alpine form that is true to the name of the Japan Alps. At their summits is developed a topography due to the erosion of small Pleistocene glaciers. This important fact was discovered by Dr. N. Yamasaki.[272) 273) 274) 275)]

It was Professor K. Oseki that was keenly interested in the glacial topography and studied it.[276) 277) 278) 279) 280)] T. Kato investigated the glacial topography in a part of the Hida Mountains with Dr. N. Yamasaki, and he entertained an original view on glacial topography. His view, to the author's regret, had not a chance to be published.

The problems on glacial topography were discussed in detail in several papers by Dr. Yamasaki and K. Oseki, and the present author published papers on glacial topography.[281) 282)] H. Tanakadate also published a report on glaciation in the mountainlands in Japan.[283)] Besides those, there are papers by Dr. T. Ogawa and S. Tanaka. In those papers they maintained that not only the higher parts of the Hida Mountains but even the lower part of the Azusa Gawa Valley were glaciated.[286) 287)] T. Kato had some doubts about the nature of the so-called "Hettner Stein,"[288)] which had been regarded to be a boulder. Thus, on the scale of past glaciers, there are points in which Japanese

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* Chapter 11, "Topography of Japan," published by the Kokon Shoin, Tokyo, 1929.

scientists do not yet agree. However, many Japanese geographers are inclined to affirm the Pleistocene glaciation.

Japanese geologists showed various attitudes to the glacial problem in Japan. It was Dr. K. Jimbo that published a negative view most decisively. In a paper on the climatic change in the post-Pleistocene, Dr. M. Yokoyama drew a conclusion to the effect that in Japan there was the coral reef period in the same geological age as the European and American Glacial Period, and there is no evidence of glaciation in Japan.[289] However, in his later paper on the Pleistocene fossils from Awa Province, he described that it is not always necessary to deny glaciation in Japan.[290] Dr. H. Yabe was affirmative from the beginning to the existence of glaciers in the Pleistocene Age.[291] According to Dr. Yabe, when the problem of climatic change in the younger geological age is discussed, it is necessary to determine the geological age of the stratum. Moreover, the deposits in the vicinity of Tateyama in Awa Province where fossil tropical shells were found by Dr. Yokoyama can be explained to be the deposits in the warm period in the post-Pleistocene. A criticism to the above-mentioned discussion on glacial problem was made by Dr. Yamasaki.[292]

The existence of cirques draws geographers' attention most in the high mountain districts in Japan. To make clear the significance of this peculiar topography, it is necessary to clarify the following respects. First, the mechanism of cirque formation must be considered as strictly as possible, as it has been found that there is a close relation between cirques and glaciation. But there are some questions

as to the process of glacial erosion. The second problem is whether the identification of the form of cirque has been made accurately or not. Thirdly, it is necessary to observe the distribution of cirque topography.

The formation of cirque has been explained in various ways. Of those, the following explanation was given by Bowman[293) 294)] recently. According to him, the agency for cirque formation is glaciation and nivation. However, nivation meant by Bowman, as known by the study of Mathes,[295)] is not of small scale, but means erosion of flowing névé. Therefore, nivation meant by him is considered to be a kind of glaciation. There must be series of topography due to glaciation and nivation in various stages, beginning with the topography formed by nivation in a long period, from the topography formed by glaciation in a short period to the topography formed by glaciation in a long period.

To determine the form of cirques accurately, the above-mentioned relation must be considered to the full. If there is a man who, on the sole ground that there is an ill-developed form, doubts even the origin of typically formed cirque, he is mistaken just as a man who, on the ground of existence of ill-formed crater-like depression, doubts even the origin of well-formed crater. In the high mountain districts in Japan, there are not a few cirques which have quite the same forms as those in foreign countries regarded to have been formed by glaciation.

The form of cirques formed by glacier in the past has been usually more or less modified by weathering in the post-Glacial Period. The degree of modification is controlled by the nature of rocks and the intensity of weathering. Therefore, the degree of modification is not

far from equal according to district and the length of time which elapsed in the past Glacial Period. By comparing cirques destroyed to different degrees and glaciated to different degrees, to conclude that they were of quite different origin is unreasonable. Many cirques in Japan, as compared with typical cirques in Europe and North America, have been modified in their forms.

The distribution of cirques shows that there is a definite law controlling the distribution, and it is clearly shown that their vertical and horizontal distributions have direct relation to the amount of snowfall. According to Dr. Yamasaki, the altitude of cirque bottoms is 2550 meters on an average in the Hida Mountains. Accordingly, the position of topographical snow line in the past also can be obtained approximately. The bottom of Senjōjiki Cirque in the Kiso Mountains is situated in the altitude of about 2600 meters. The bottom of the cirque in Senjo Dake in the Akaishi Mountains is 2650 meters. This problem seems to be solved not only by observed facts but also a statistical study. It is quite distinct that the condition of snow lying has remarkable influence on the horizontal distribution of cirques. It is a conspicuous phenomenon that most of cirques are found on the slopes facing the northerly or easterly direction. Needless to say, the relation is controlled by sunshine and wind direction. At present the similar phenomenon is seen in the condition of lingering snow. There are many observations in the horizontal distribution of cirques. The recent one is cited below.

According to Vitasek, the total number of cirques in Niedev Tatra in the Carpathian Mountains is 28, and they are grouped as follows:

according to the directions to which they face: N 9, NE 7, E 2, SE 1, S 2, SW 1, W 0 and NW 6.[296] In the Hida Mountains, though there are one or two cirques facing NW as seen in Tate Yama and Goro Dake, most of them face E or NE. Other groups of cirques in the above two mountains are limited to the slopes of the eastern and northern sides.

In the greater part of cases, due to the asymmetrical distribution of cirques, quite different topography is developed in each side of the ridge. The most simple case is that in which cirques are developed in one side of the summit. The case is represented by Nakanata Dake and Harinoki Dake in the Hida Mountains. The case in which more than two cirques are arranged in one side of the ridge is most common in high mountains in Japan. Kura Take and Yakushi Dake are the most typical examples.

In Japan it is very rare that the density of cirques becomes larger, ridges and summits are glaciated maturely, and sharp crests and saw-toothed ridges are formed. In the upper parts of Hotake Take and Yari-ga Take in the Hida Mountains rock ridges and sharp crests that are nearly the same as the above-mentioned condition are developed. In the Akaishi Mountains there is only one example. That is to say, the form of the summit of Senjo Dake somewhat resembles the above-mentioned condition. In O Yama of the Tate Yama Range there are four cirques in the eastern side, while there is one cirque facing northwest in the western side. There is an evidence that a pretty typical ridge was formed between the two sides.

From the foregoing facts, it is clearly understood that glaciation in high mountains in Japan in the past was of small scale, most of them were small glaciers in cirques, and rarely short and small valley glaciers were developed. As to the intermediate type between cirque glaciers and valley glaciers, and transition from cirques to glacial troughs, a case of the Mission Range in Montana described by Davis serves as a good example.[297)] A cirque in the eastern slope of O Yama of the Tate Yama Range seems to be one that is going to become a glacial trough. The existence of a U-shaped glacial trough on the slope of Hotaka Take was pointed out by Oseki.[276)]

As the degree of glaciation was not remarkable and erosion after the disappearance of glaciers was remarkable in high mountains of Japan, it is rare that rocks ground by glaciers are exposed on cirque bottoms. The greater part of cirque walls are covered by talus. Accordingly, sharp alpine peaks and rock ridges have gradually disappeared. Moreover, in most of high mountains in Japan the summits were the forms that may safely be called Schneiden. On the other hand, it is considered that, in spite of large altitude, it was unfavorable to the development of glaciers. So the contrast between the steep cliff of rock walls and gentle slopes in the vicinity must not have been comparatively remarkable. The steeper the mountainland the more quickly glacial topography and glacial deposits must have been destroyed.

In spite of such an unfavorable condition, distinct moraines are found in the Hida and other mountains. A terminal moraine deposited by a small glacier was discovered by Dr. Yamasaki at the end of a cirque situated in the northwestern side of O Yama of the Tate Yama Range.

The present author also observed a terminal moraine in a cirque in the eastern side of the same mountain. Besides these, terminal moraines can be seen in Yakushi Dake, Yari-ga Take, and Karinoki Dake of the Hida Mountains.

In the Kiso Mountains there is a topography to be considered a terminal moraine below the Senjojiki Cirque in the southeastern side of Koma-ga Take. According to Noda, No-ga Ike seems to be a small lake formed inside of a terminal moraine just as Goro-no Ike of Goro Take. In Japan there is no lake which was formed in a depression due to glaciation. Such lakes may have been formed, but they were probably buried by talus. In the Akaishi Mountains there is a distinct moraine in a cirque of Senjo Dake. Another moraine was reported from the vicinity of Onagochi Dake.

It is flora and fauna, particularly flora that has a close relation to the problem of climatic changes in the Pleistocene.

According to several papers ever published, the distribution of alpine or frigid zone plants in the high mountain districts in Japan is an evidence of the cold climate in the past age, though there are some views against it.

When the climate in the past age is presumed based on the distribution of plants, mistakes due to various causes are liable to be made. For example, when the botanical zones in the Pleistocene is presumed based on the relic flora, it is absolutely necessary that the relation between the climate in the recent age as well as other conditions and the ecology of plants is made clear. Particularly, besides the relation

between the air temperature and the distribution of plants, the influence of the nature of the place must not be neglected. Therefore, even if the plant which flourishes on the summit of a high mountain is found in the low place on the flank or a low mountain, it cannot be determined that the very plant flourished in an extensive area in the vicinity.

Supposing that alpine plants are growing on a rock cliff developed in a small altitude, to determine them to be a relic flora representing the flora in the Glacial Period, it must be proved that the above cliff existed in the same place from the Pleistocene up to the present. Generally speaking, exposed rocks are supposed to exist only in a short period. Therefore, there are not a few questions in the respect. If it is supposed that there were many rocky places in the area, and they were formed in succession and destroyed in succession, the above difficulty can be exempted. However, when considered prudently, besides them, many complex problems are contained.

It must be considered that in the region where crustal movements occur frequently like Japan, the remarkable changes of altitude of mountainland must have occurred after the Pleistocene. Accordingly, in most of mountainlands, the altitude must have been increased as compared with the altitude in the Glacial Period, while in the small number of them the altitude must have decreased.

From the fact that uplift as much as 300 meters to 500 meters occurred in the littoral areas in Japan in the past, it can be presumed that the change of altitude of equal scale took place in mountainlands. Even if the downfall of the botanical zones and snow line

occurred not in the distant past, to know the amount of vertical change accurately, besides the apparent amount of vertical displacement, the vertical displacement of the ground must be taken into consideration.

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Section VI Mining industry

1. General description

There is no important mineral deposit in the South Sea Islands under the Japanese mandate except phosphate ore. Besides phosphate ore, sulphur, manganese and lignite are found in the islands. However, those deposits are small and almost valueless economically. Though manganese was mined and exported about 1917, the mining was stopped soon after because of the poor deposit. Phosphate ore is found mainly in Angaur Island. The ore is also found in Fais, Peleliu and Tobi but the deposit is small. In Angaur the mining of phosphate ore is being carried out by the South Seas Government. The government has a claim to mine phosphate ore in Fais and Peleliu. However, the government has not yet set to work.

2. Phosphate ore in Tobi

An enterpriser was authorized to mine phosphate ore in Tobi. However, as he did not set to work due to shortage of capital, the authorization was withdrawn. In August 1931 another enterpriser was authorized to mine phosphate ore in the island. The authorized area was 142,695 tsubo*, and the total deposit was estimated to be about 120,000 tons.

3. Phosphate mining in Angaur

Formerly the mining of phosphate ore in Angaur was carried out by

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*Translator's note: 1 tsubo is equal to about 6 square feet.

the German Phosphate Company since February 1909. The company was in Bremen, and the capital was 4,500,000 marks. After 1914 the mining was put under the control of the Japanese Navy. The navy organized the Association of the Development of the South Seas, and made the association carry out the mining from January to April 1915. After that the mining was transferred to the government, and the government made the temporary defense forces carry out the mining business.

In 1922 the South Seas Government purchased not only the mining right but the land, buildings and machines for 1,739,960 yen together with the mining right of Fais and Peleliu possessed by the German Phosphate Company. Since then the Mining Bureau is working the mining under the jurisdiction of the Governor of the South Seas. The phosphate ore in Angaur is classified into 2 Kinds:--red ore and white ore. The ore in the upper layers is deeply colored, while the ore in the lower layers is lightly colored. As to the form, the ore is classified into 3 Kinds:--powder, granule and block. Generally speaking, white ore is of good quality. The deposit was estimated to be 3,000,000 tons in the German occupation age. However, in the end of 1931 it was estimated to be about 1,500,000 tons when refined.

Since the transfer of the mining to the South Seas Government about 60,000 tons of phosphate ore have been mined annually. The phosphate mining is an important source of revenue to the South Seas Government. The ore is dried, made into refined ore, and is sold to companies in Japan.

4. The Mining Bureau

As stated above, in March 1922 the organization of the Mining Bureau of the South Seas Government was proclaimed by No. 109 of the Imperial ordinance. The bureau deals with the business respecting the phosphate mining under the jurisdiction of the governor of the South Seas. The bureau consists of a technician, assistant technicians and clerks. The chief of the bureau is a technician. (Since 1922 a technician, 7 assistant technicians including clerks, and 7 employees.) The business of the bureau is classified into 8, that is, general affairs, finance, mining, investigation, vessels, machines, works and sanitation.

Most of workers and miners are the natives. The works that require technical skill are made by the Japanese, Chinese, and the Chamorro, while mining as well as transportation are done by the natives. The native workers are invited from Angaur, Palau, and Truk. The number of native workers is not fixed. The necessary number is about 400.

The amount and sum of money of mined and exported phosphate ore are given below.

Phosphate Ore

Year	Mined ore	Exported refined ore	Sum of money (yen)	Administrator
	tons	tons		
1912	13,742	9,620		German Phosphate Co.
1913	42,465	29,726		"
1914	59,957	21,026		"
1915 (Jan.-Apr.)	13,374	23,090		Association of the Development of the South Seas
1915 (May,-)	15,736	4,814		Temporary Defence Forces
1916	51,598	35,713		"
1917	53,202	47,505	1,132,131	"
1918	68,799	56,699	690,810	"
1919	89,322	73,685	1,419,718	"
1920	74,341	55,552	1,039,997	"
1921	66,823	54,868	1,477,910	"
1922	51,314	56,300	1,019,897	Mining Bureau
1923	74,108	59,987	1,049,772	"
1924	80,617	60,657	1,097,891	"
1925	100,686	65,864	1,320,573	"
1926	78,078	62,912	1,299,132	"
1927	96,735	63,128	1,335,157	"
1928	77,740	64,326	1,386,225	"
1929	84,227	64,459	1,414,875	"

1930	71,853	55,455	1,153,464	Mining Bureau
1931	69,085	59,251	1,125,769	"

The expense and income of the phosphate mining industry, and the number of workers and miners are given in the following tables.

The expense and income of the Mining Bureau

Year	Income Sale of ore	Expense						Profit
		Salary	Business expense	Mining expense	Various expense	Repair expense	Total	
1922	yen 1,019,897	yen 24,035	yen 40,688	yen 197,034	296 yen	yen 27,743	yen 289,796	yen 730,101
1923	1,049,772	17,066	26,539	358,530	228	44,834	447,197	602,575
1924	1,097,891	18,489	25,042	343,201	239	32,035	419,006	678,885
1925	1,320,573	22,283	16,960	342,312	449	47,727	429,732	890,841
1926	1,299,132	22,071	16,522	350,304	744	47,851	437,495	861,637
1927	1,335,157	21,953	14,297	329,866	578	87,707	454,404	880,753
1928	1,386,225	19.927	13,733	376,720	1,149	52,508	464,038	922,187
1929	1,414,875	15,819	13,878	348,116	278	47,926	426,019	988,856
1930	1,153,463	17,135	11,422	315,355	389	47,831	392,135	761,328
1931 (Expected)	1,159,000	22,972	17,070	365,000	500	48,000	453,542	705,458

The number of workers and miners

Year	Japanese	Chinese	Chamorro	Kanaka								Total	Total
			Angaur	Angaur	Palau	Yap	Mokumoku	Oleai	Fais	Truk	Nomoi		
1922	15	12	28	19	69	209	24	50				399	426
1923	31	12	27	15	57	195	24	46		32		396	439
1924	63	12	22	14	67	162	25	44		66		400	475
1925	71	11	27	13	51	127	14	50	20	57		359	441
1926	67	10	25	6	47	89	13	46	20	91	55	392	469
1927	71	9	29	7	48	98	14	45	22	3	148	414	494
1928	70	6	27	9	34	106	13	46	18	131		384	460
1929	70	4	25	16	38	92	14	39	17			241	315
1930	76	5	23	14	37	77	13	38	16	120		338	419
1931	80	4	27	18	36	66	12	37	13		140	349	433

3⁰⁰

U.S. Geological Survey. [Pacific Geological Surveys. Reports]

ON LAKE NGARDOK, SOUTH SEA ISLANDS
(BABELTHUAP ISLAND, PALAU GROUP)

by Yoshine Hada
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Hokkaido University

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On Lake Ngardok, South Sea Islands
(Babelthuap Island, Palau Group)

by Yoshine Hada
(A member of the Akkeshi Marine Laboratory,
Science Department, Hokkaido University).

I studied Lake Ngardok, the only lake in the South Sea Islands, in February 1931 with the assistance of Hori Naganzisu, an engineer of the Colonization Department, the South Sea Islands Government Office, and the Palau Branch Office of S.S.I. Government. Here, I want to express my hearty thanks to them.

Lake Ngardok is on the Island of Babelthuap, the largest of the Palau Islands and called the main island of Palau by the Japanese. In 1872, Cooberty (Kubary?) had already reported the presence of this lake. The easiest route from the Island of Koror to this lake is as follows: One can sail by motor boat under the management of native inhabitants from Koror to Melekeiok, a native village on the east coast of the Palau main island, from which one may walk to the lake in about 2 hours (dotted line on figure I shows this route).

The main island of the Palau group is, next to Ponape, the largest one in the South Sea Islands, and its area is about 60 sq. km. The island is largely underlain by volcanic rocks, with the exception of a small area in the southeastern part. A ridge runs longitudinally through the middle part of this island, and near the east coast there is a small ridge parallel to the first. Between these two ridges flows the longest river on this island. Its course is more than 10 km. long. Ngardok is a stagnant part of the river. Therefore, it is more correct to call this a marsh than a lake, considering its characteristics, but it generally is spoken of as a lake. Thus, I followed the same custom in the present paper.

The shape of the lake is long and narrow, and its depth is not great because of the origin of it. The peripheral parts of this lake are swampy and here many kinds of plants grow luxuriantly. Fensch described this lake in his paper "Ergebnisse der Sudsee-Expedition, 1910" as follows: "its length, width, and depth are respectively 1 km, 400m., and 4m." However, according to a survey by the South Sea Island Government Office, the length of this lake is about 909m. and the maximum width is

29m. Therefore, there is an appreciable difference between these two measurements. These differences may be due to inclusion or exclusion of the swamps in the periphery. Inasmuch as Fensch's method of measurement is not known, the author recognizes the survey of the South Sea Islands Government Office as correct and has used those measurements. According to the Land Surveying Department, S.S.I. Government Office, the area of this lake is about 16 sq. km. The deepest part lies relatively near the outlet, and the depth was estimated by me to be 4m. which exactly coincides with Fensch's measurement. However, the larger part of the lake shows depths of 3 to 3.5m., and near the inlet, 1m. A rich deposit of humus and mud is found on the bottom which is entirely covered by water-plants.

The inlet is not easily seen because of the luxurient vegetation, but the outlet has a width of about 3m. and a slight current. The surface of this lake is 25m. above sea level, according to Fensch's measurement.

Some Investigations

Concerning water temperatures, I measured the surface temperature at intervals from the afternoon of February 8th to the afternoon of the 9th at point S as indicated on figure 2. The results are shown in table I. From these, one can see that the difference between the maximum and minimum temperatures is only 2.8°C. This difference is the variation of the temperature of the surface water throughout one day. Inasmuch as the variation in temperature throughout a year in this district is very small, it appears to me that the yearly variation in the temperature of the water may be the same as the daily variation.

TABLE I

Date February 1931	Weather	Time	Atmospheric Temperature °C	Water Temperature °C
8th	Clear	P. M. 12:30	28.5	29.1
"	"	" " 5:00	27.0	29.2
"	"	" " 8:00	26.8	28.0
"	"	" " 10:00	26.2	27.8
9th	"	A. M. 4:20	25.8	26.8
"	"	". " 6:30	25.8	26.4
"	"	" " 9:00	27.3	26.8
"	"	" " 10:00	28.2	28.0
"	"	P. M. 1:00	29.5	29.2

The daily variation in temperature of the water with depth is rather small because of the shallowness of the lake. This is illustrated in Table II.

TABLE II

Date February 1931	Time	Stations (see fig. 2)	Depth of Water	Atmospheric Temp. °C	Temp. of Surface Water	Temp. of Bottom °C
8th	P. M. 2:30	A	4.0 M	27.9	29.5	25.3
"	" " 3:10	B	3.2 M	27.5	29.5	26.2
"	" " 3:50	C	1.3 M	___	29.2	___
9th	A. M. 10:00	D	3.5 M	29.5	27.7	25.6
"	" " 10:30	E	3.5 M	29.2	27.8	20.1 (?

The general characteristics of this lake are similar to those of lakes in peat districts, the water has a brown color, its transparency is very low (the degree of transparency using Secchi's disk is 1.8 - 1.9 M). The water of Lake Ngardok is slightly alkaline and has a pH value of 7.8 to 8 by the colorimetric method. In these two characteristics, degree of transparency and pH, I could find no variation at different places in the lake. I think that the alkalinity of the water may be due to the influence of water-plants at the bottom.

No mammals live in the vicinity of the lake, but I found several kinds of aquatic birds. These birds are very common on the surface of the sea in this general area, so it is very clear that the birds on

the lake came from the sea. I found several eggs of one kind of Sterna (tern) on the lake shore, and I observed that some of these sea birds nest on the lake shore. Of the land birds, there are many pigeons (a different species from the pigeons of Japan proper) and several kinds of small birds. Of reptiles, there are many kinds of lizards. Of amphibia, one kind of frog was formerly reported but I never found it and never heard it during my investigation. Two kinds, of fish live in the lake, one of them a large tropical eel, and the other a kind of Casassius which is commonly called the South Sea Casassius. Both of these fish generally live down stream rather than in the lake.

PLANKTON

The development of plankton is very poor. Lake Ngardok is typical of lakes containing little food for their development. Of the plankton plants, diatoms are very scarce and only a few green algae were noticed. Of the plankton animals, there are many rotatoria and Protozoa. Besides these, I found one each of Nematoda, water-tick, and copepoda, and many copepods in the larval stage.

There are many kinds of rotatoria, and I found one species of each of the following: Euchlanis, Monostyla, Rattulus, and Rotifer, as well as two species of Cathypna. The number of species and individuals of both genera are few.

Among the following Protozoa there may be included some animals which are not plankton in the strict sense but here I include as plankton, all kinds of animals which were caught in a plankton net made from No. 25 silk.

Of the Protozoa, those most commonly found are Rhizopods with shells. I identified the following 5 species:

Difflugia sp

Arcella vulgaris, Ehrenberg

A. costata, Ehrenberg

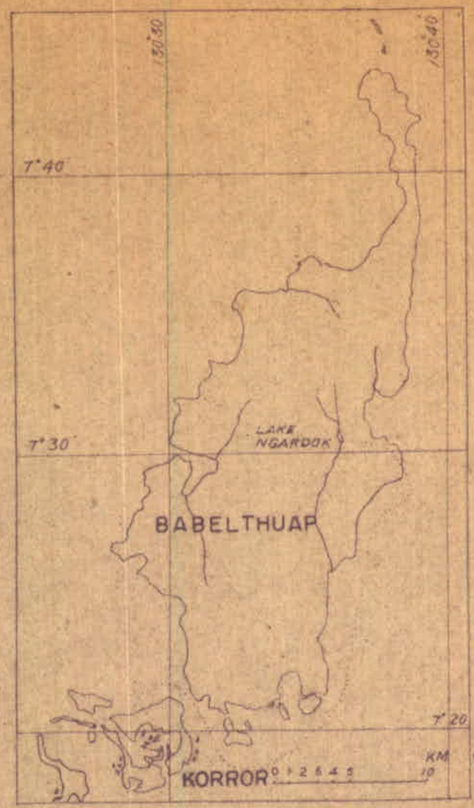
Euglypha alveolata, Dujardin

Guadrula symmetrica, Schulze

The number of individuals of the 2 species of *Arcella* are relatively common, as compared with other genera.

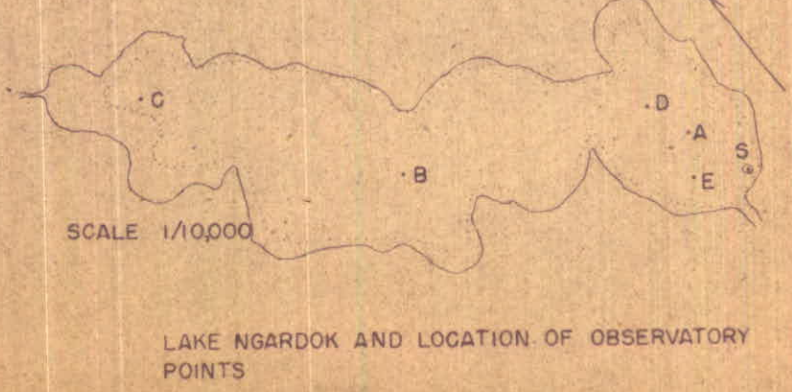
Of the *Flagellata*, I found an *Euglena* sp., and ellipsoid form with a short appendage at the end of its tail. The total length of this specimen is about 45 μ. Besides this species I also noticed a very small-sized Gymnodinium sp., the length of which is 15 to 18 μ. The Gymnodinium sp. was the more common in the plankton collected from the lake.

FIG. 1



INDEX MAP SHOWING ROUTE FROM KORROR ISLAND TO LAKE NGARDOK

FIG. 2



LAKE NGARDOK AND LOCATION OF OBSERVATORY POINTS

LIMITS OF THE SWAMP

3º¹

GEOLOGICAL OBSERVATIONS ON IWOJIMA

By

Fujiro HOMMA

Chikyū (The Globe), Vol. 4, No. 4, pp. 30-49, 1925

PART I. FROM YOKOHAMA TO MINAMI IWOJIMA (pp. 30-37).

Translated by K. MUSYA January 1950
Translation edited by H. L. Foster March 1950

PART II. GEOLOGY OF IWO-JIMA (pp. 37-49).

Translated by T. SAKAMOTO July 1949
Translation edited by H. L. Foster December 1949

[Note: Discrepancies exist between Parts I and II in spelling of place names and authors' names in references because each part was translated by a different Japanese translator.]

Pacific Geological Surveys
Military Geology Branch, U. S. G. S.
Tokyo, Japan

GEOLOGICAL OBSERVATIONS ON IWOJIMA

By

Fujiro HOMMA

PART I

FROM YOKOHAMA TO MINAMI IWOJIMA

Chikyu (The Globe), Vol. IV, No. 4, pp. 37-49, 1925

Translated by K. MUSYA January 1950
Translation edited by H. L. Foster March 1950

Part I

Illustrations

Part I

The photographic illustrations accompanying this report are too poor for reproduction, however, the titles are listed below:

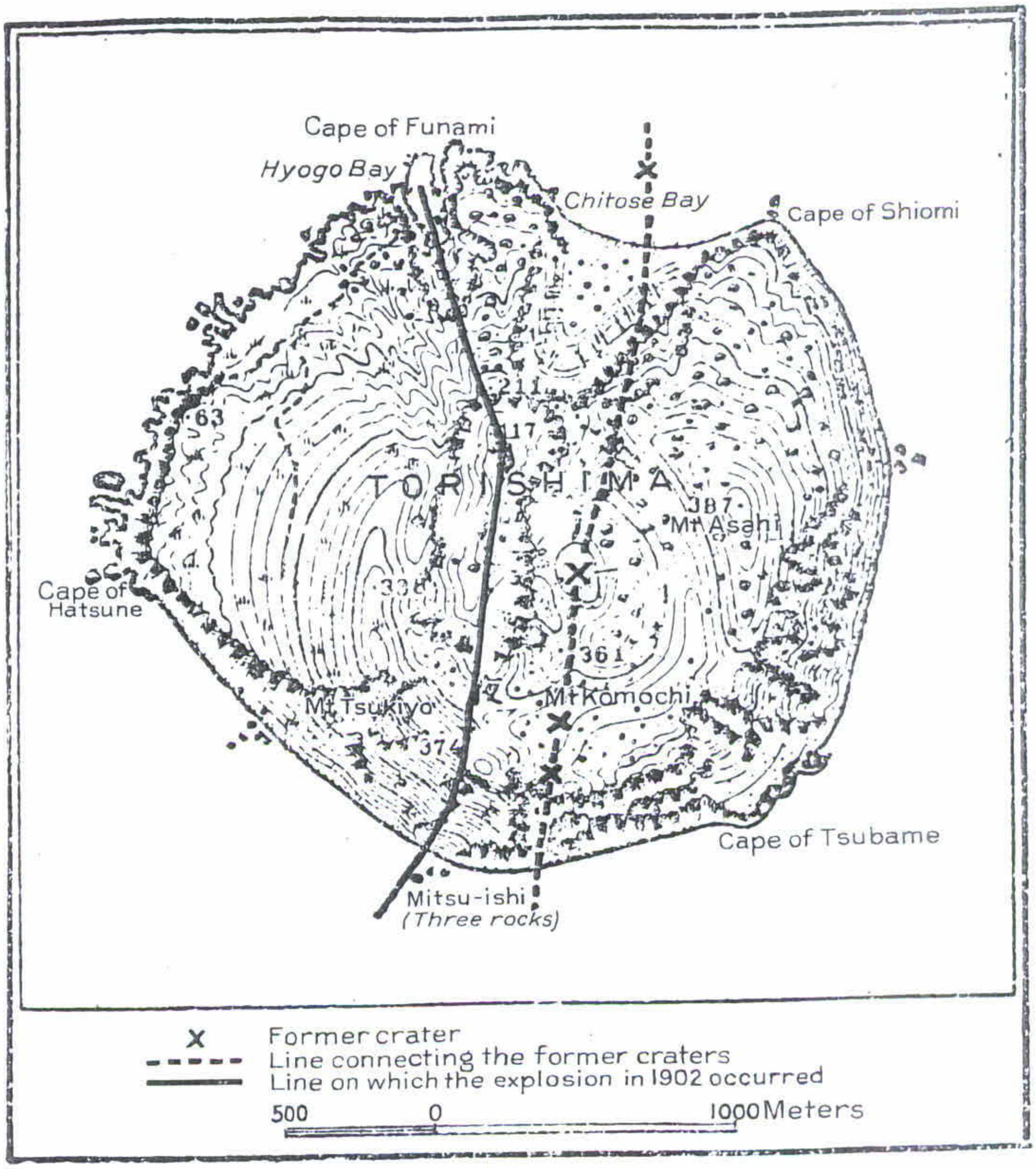
Part I

FROM YOKOHAMA TO MINAMI-IWOJIMA

By
F. HOMMA

A regular liner which sails every 20 days makes a call at Naka-Iwojima only once in 3 voyages. I left Yokohama at 14 o'clock and reached Hachijo-jima at dawn on the next day. Hachijo-jima is composed of 2 volcanos arranged from northwest to southeast; that is, Nishiyama (854.3 meters above sea leve) and Higashiyama (700.9 meters above sea level).. Nishiyama is a young conical volcano, while Higashiyama has been dissected so much that it does not present the appearance of a volcano. Precipitation is heavy in Hachijo-jima. Thus the rivers which rise from Higashiyama are dry only part of the year. There is a hydroelectric power station on the island, a feature which the other volcanic islands do not have.

After several hours I left the island and arrived at Torishima. A violent volcanic explosion occurred on the island from the 7th to 9th of August, 1902. The crater at the summit was blown away, and a new bay was formed on the north coast. There were 125 inhabitants at that time. They were killed when they and their houses were buried. Even now hot springs gush out here and there. At present there are 31 inhabitants who have moved to the island since the above-mentioned explosion. It was pointed out by Dr. Kikuchi[1)]


Cape of Funami
Hyogo Bay
Chitose Bay
Cape of Shiomi
63
17
TORISHIMA
387
Mt Asahi
Cape of Hatsune
361
Mt Komochi
Mt Tsukiyo
374
Cape of Tsubame
Mitsu-ishi
(Three rocks)
Former crater
Line connecting the former craters
Line on which the explosion in 1902 occurred
500 0 1000 Meters

that the island is a double volcano.

Leaving the island, I arrived at Futami, Chichi-jima, the next evening. It impressed me as a curious land because there were coconut groves on the sand beach and there was dark brown laterite. The Ogasawara Islands which have been subjected to marine, wind, and fluvial erosion, are at present a group of hilly islands without plain. In the history of geology the islands are famous as the locality where nummulites were found for the first time in Japan. Investigators of structural geology are interested by the existence of the Paleogene formation. The islands are of historical petrological interest because they were the stage on which the oldest volcanic activity of the Fuji Volcanic Zone in the Tertiary Period was played. Also, boninite is found there. The complex fold of agglomerate of boninite at the Lion Head is the best example for showing the creep of volcanic detritus in the sea-bottom.

In Minami-jima karst topography is highly developed. Pure white shells which cover the limestone at the Cape of Minami-zaki form a shell beach. Since the shells are blown by the wind, they are found even at localities which are several tens of meters high. Thus, the Minami-jima Peninsula has the appearance of a powdered face. On the way back I speared several large beautiful fish, and caught large lobsters and octopus

KITA-IWOJIMA (1:50,000)

which were a few kilograms in weight.

After 1 to 2 days' stay at Chichi-jima I went to Haha-jima which is 35 nautical miles from Chichi-jima. Abundant nummulites could be obtained on the island by going on foot only 1 or 2 kilometers from the village of Oki. Mt. Sekimon which is situated 5 kilometers north of the village is composed of milky white limestone Karst topography is developed. The deep blue sea as seen through the deep green tropical grove was very beautiful. Pink tuff found in the village of Oki is a good building stone and an important rock which geologists must not overlook. However, it is difficult to make observations throughout the island, because the time of stopping there is only a few hours.

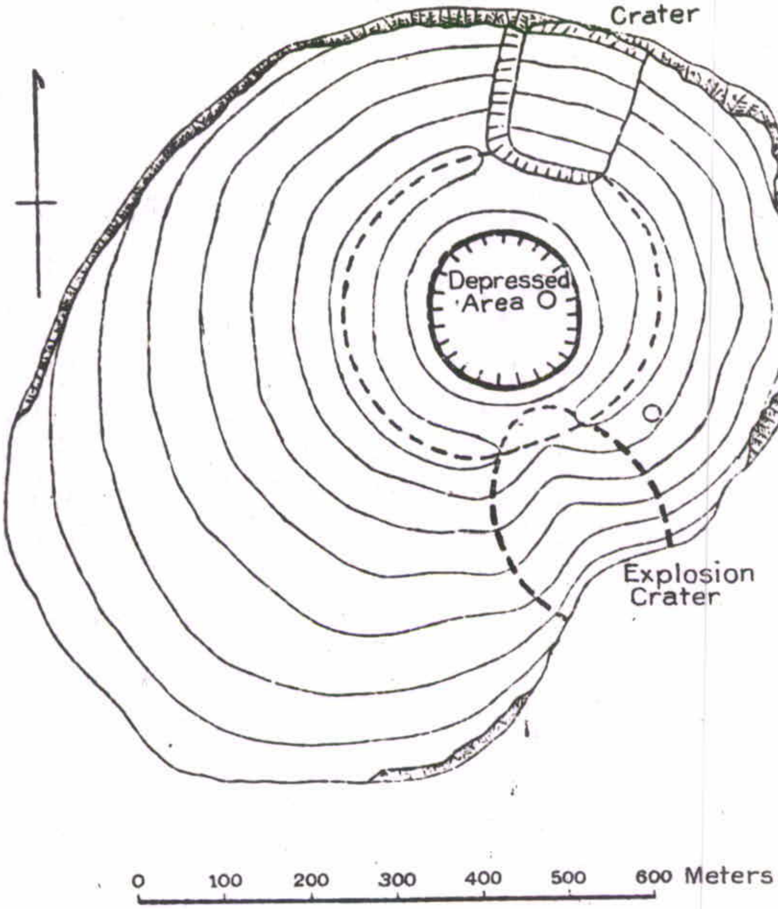
Kita-iwojima is situated 85 nautical miles south southwest of Haha-jima. Our ship whistled and a boat left the foot of the cliff and approached our ship. The part above the cliff of the island is very steep. The slope is 45°. However, there is a small gentle slope which was produced by the ejectamenta thrown out at the time of volcanic explosion and by some later debris. The village is situated in such a locality. East of Mt. Sakakigamine (804 meters above sea level), the highest peak of the island, there is a small crater[1]. South of the crater

is a horseshoe-shaped depression caused by an explosion or landslide. Dr. Wakimizu also pointed out an explosion crater opening to the northeast in the northeastern part of the island which is more than 800 meters in minor diameter[4]. On the basis of the dip of the lava and beds of detrital material, it is concluded that the locality must have been the center of volcanic activity. This island is situated in the Fuji Volcanic Zone, and its formation may have been quite recent. However since at present it is being eroded by the waves, there remains only a trace of the island of former days. The rock of this island is olivine-bearing pyroxene-andesite, which has a fairly well crystallized groundmass. Olivine, upon being decomposed, has become a blue material. The rock also contains a small quantity of rhombic pyroxene.

I left Kita-Iwojima and arrived at Iwo-jima 38 nautical miles south of Kita-Iwojima. It was at dusk when I landed by a lighter on the dark gray sand beach. When I climbed Mt. Motoyama which is two kilometers from the beach, night had completely fallen, and the sky was sprangled with stars. The island stretches from 24°45' N. to 24°48.5'N. and from 141°17' E. to 141°20' E. It is a volcanic island 703 nautical miles south by east of Yokohama.

Minami-Iwojima is about 35 nautical miles distant from Iwo-jima. It is an uninhabited island. Since on rare occasions are persons are cast ashore on the coast, the ship visits the island twice a year. On the seabottom about 3 nautical miles northeast of the island a volcanic eruption occurred around the 28th of January 1904, and before the 5th of December a volcanic island was formed. The newly born island was composed of pumice and volcanic ash and was over 4.5 kilometers in circumference. Around the 16th of June in the next year the island almost disappeared, and it looked like a whale back. The submarine eruption was described by Dr. Wakimizu[4).

Volcanic eruption took place again at the same spot on about the 23rd of January 1914, and a volcanic island was formed[5). The island was 130 meters high, and less than 3.8 kilometers in circumference. It was composed of pumice and volcanic ash. That island almost disappeared at the end of September in 1915. The eruption was described by Mr. Ogura and Mr. Toyoshima[8). The cause of the disappearance was discussed by several scholars who went to investigate the newly born island. Investigation made by Mr. Toyoshima was most detailed and excellent, and his investigation was published in the magazine "Science and Arts of the Orient" by Dr. Wakimizu[8). According to Mr. Toyoshima, the disappearance of the island was not due to an explosion but to marine erosion caused by the prevailing east and northeast winds.



KITA-IWOJIMA

GEOLOGICAL OBSERVATIONS ON IWO-JIMA

By

Fujio HOMMA

PART II

GEOLOGY OF IWO-JIMA

Chikyū (The Globe), Vol. IV, No. 4, pp. 37-49, 1925.

Translated by T. SAKAMOTO, July 1949
Translation edited by H. L. Foster, December 1949

Part II

The photographic illustrations accompanying this report are too poor for reproduction, however, the titles are listed below:

Part II

GEOLOGY OF IWO-JIMA

by
F. HOMMA

As long ago as 1783, the ship "Resolution", on a Pacific Expedition, first visited this island. It was commanded by Mr. Gare who succeeded Mr. Cook after his death. Because of the clouds of sulphuric vapors which they saw rising from the island, they named it "Sulphur Island". They called North Iwo-Jima San Alessandro Island, and South Iwo-Jima San Augustino Island. The inhabitants even now call the islands by these names. Iwo-Jima is also called "Naka (Middle) Iwo-Jima" by strangers in order to avoid confusion. There is no "Naka Iwo-Jima" on the map surveyed by the Army Surveying Division.

Geomorphologically, Iwo-Jima, as has already been noted by many geologists, is a unique flat volcanic island consisting almost entirely of tuffs. Only a tiny conical volcano, Pipe-yama (166.7 m.), at the southwestern end of the island, breaks the monotony of the landscape. The island is triangular. It is a little over 4 km. long in a northwest-southeast direction and less than 8 km. long in a northeast-southwest direction. It has 10 (northeastern shore) or 6 steps leading up to the highest flat terrace. Moto-yama (the highest point 114.8 m.) as Dr.

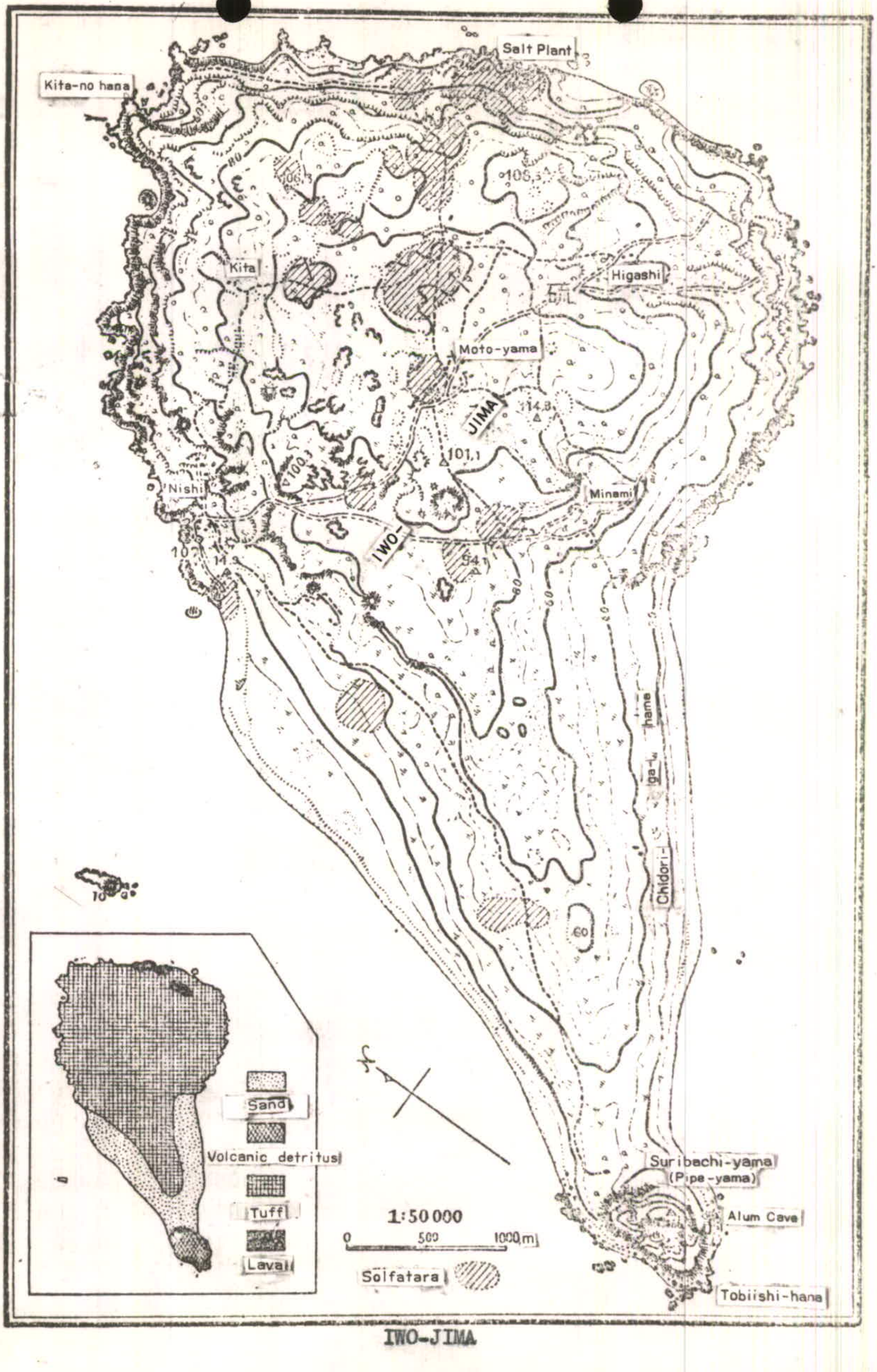
Kikuchi said, metaphorically "looks like patches in tiers upon the mountain side". Each of these terraces is several meters to over 20 m. high, and was formed, as has already been proved by reasons stated later in this report, by discontinuous upheaval of the sea bottom.

Iwo-jima, as is indicated by its name, has many active and extinct solfataras, all over the island. The position of extinct solfataras are indicated by patches of waste land in shallow depressions. The area between Moto-yama and Pipe-yama, 4 km. in length, used to be a regular desert that caused much trouble to a traveller, but now trees have grown. The divide of the island runs through the middle of the area, roughly parallel to the long dimension of the island. The south-eastern flank of the divide slopes uniformly with a gentle gradient into the sea. The northwestern flank, however, has a cliff, several meters to 20 m. high, running nearly in north-south direction close to the divide, and then gently sloping down to the beach. Beds of volcanic debris which are cemented by iron oxides were tilted eastward. Then these beds were cut by a line of fractures. Probably solfataras which trend north-south were present along the fractures. Later the rocks up to this line of fracture were eroded comparatively easily by the waves and the present topography resulted.

Pipe-yama has a crater on the summit, which is the shape of an inverted cone. It is an active solfatara. Its mouth opens to the northwest. On the southeastern coast is a cave in an eroded solfatara containing white, powdery alum. The topography is caused by tuffs, agglomerates, and small amounts of lava of an alkaline volcanic rock, which is rather unusual in the Fuji volcanic zone. The tuffs are nearly horizontal, but in places have dips up to about 40° toward the beach. The gentle slope on the southeastern flank of Moto-yama has no terraces and is nearly a dip slope. Generally, terraces cut the tuff beds into a flat plane, leaving rounded pebbles or a bed of pebbles upon it. The pebbles clearly show that the plane is a wave-cut terrace. Also, corals of Recent age which were left upon the terrace were noticed by Dr. Wakimidzu.

A lava outcrop was found by Dr. Kikuchi[1] at the base of the Pipe-yama on Iwo-jima but no other localities have been reported. Petersen[2], in 1891, made a petrological study of rocks from this island, making use of the samples collected by a botanist, Warburg. Petersen gives an analysis of a glassy lava. I believe that this lava is not the one from the base of Pipe-yama. I do not know whether the oligoclase-andesite on which Dr. Kodzu corresponded with Mr. Washington[7] is the same as this or not.

As a matter of fact, as one walks along the coast of Iwo-jima, one can find pebbles of other volcanic rocks in large quantities. A resident of the island Mr. Yoshizo Ishikawa, took us to the coast due east of the Moto-yama village, and up north to a salt plant operated by Mr. Okajima. On our way, we saw small lava flows underlying the tuffs. Some of the lavas evidently are the glassy pyroxene-andesite. A group of members of the Tokyo Geographical Society passed this locality, guided by Mr. Ishikawa, so some of them must have already seen these outcrops. The presence of these lava flows does not indicate very much concerning the volcanic activity of Iwo-jima, but it proves that there are also some lavas in Moto-yama. It was formerly considered to be built only of ashes and pumice. It is not quite correct to trace the source of plagioclase sands only to eruptions from Pipe-yama, because, as is stated above, the top of hills between Moto-yama and Pipe-yama are composed of a solid bed of volcanic detritus which contains large amounts of plagioclase crystals and pieces of pumice. The glassy lava which sticks to these crystals is no doubt the same as that on the northeast coast. On the other hand, when we climb Pipe-yama, we find the beds of agglomerate containing these rock fragments and pumice. Thus we agree with the opinion of Dr. Wakimidzu[4)] that the con-


Salt Plant
Kita-no hana
Kita
Higashi
Moto-yama
JIMA
IWO-
Nishi
Minami
Chidori-ga-hama
Suribachi-yama
(Pipe-yama)
Alum Cave
Tobiishi-hana
Sand
Volcanic detritus
Tuff
Lava
1:50 000
0
500
1000 m
Solfatara

IWO-JIMA

struction of Pipe-yama and Moto-yama are not separate. Further, considering the process of upheaval of this island which shall be discussed later, the writer believes that these two form one continuous unit of activity in the initial stage of volcanism, in the way recently stated by Dr. Ogawa[10].

The fact which attracts our attention with regard to the wave-cut terraces of Moto-yama is that the upheaval of Moto-yama is not old, but is still going on at present with great speed. The writer visited the salt plant to the east of Moto-yama and made a survey with Mr. Okajima, the owner of the plant. The tip of an outcrop of a lava flow which was level with the sea on Dec. 1, 1919 when the salt plant started operating, and which was used as a foothold for drawing sea water, was as high above the sea as 10.4 shaku (3.15 m.) on Aug. 22, 1924. The rock (tuff near the coast of Minami village) upon which Mr. Okajima used to sit while fishing, was now nearly 20 shaku (6.1 m.) from the sea. In the neighborhood of Seikō (west port), though the sand beach had grown considerably, the upheaval of the tuff bed was not enough to attract people's attention. Such tilting movement as is now going on in Iwo-jima possibly means that the volcanic energy beneath Iwo-jima has not yet waned. In order to continue the observations, the writer picked three localities: the lava

on the coast near the salt plant, the tuff in Minami village, and the tuff on the landing at Nishi village. A horizontal line was marked on each of the above points at the heights respective above mean tide level: 10.4, 13.4, and 8.0 shaku (3.15, 4.1, and 2.3 m.). Mr. Ishikawa knows these marks quite well.

Other phenomena that might be connected with the volcanism are: ground rumbles accompanied by sudden earthquakes from the direction of Pipe-yama; small submarine explosions off the coast of the salt plant before the approach of an atmospheric depression. The most active solfataras are the ones near the salt plant on the northeast coast, on the west coast of Moto-yama village, off the coast of this point, and inside the crater on Pipe-yama. There is no definite linear arrangement of these and the extinct solfataras, but the line that runs northeast-southwest and passes Moto-yama seems to be an important one.

One of the recent events that attracts our attention is the fact that there were quite heavy quakes on this island during the Great Kanto earthquake. All of the water thanks for collection of rain water, which are dug in the tuff and lined with concrete, were more or less cracked. If the quakes felt on Iwo-jima toward noon on Sept. 1, 1923 were those of the Great Kanto earthquake, the distance is twice as far as that at which the tremor was felt by

men on Honshu. It is quite unprecedented and may suggest the way in which the energy of an earthquake is propagated. Even if this was an independent earthquake, but simultaneous with the Great Kanto earthquake, its meaning must be carefully considered. This is data which cannot be overlooked when we recall that Dr. Saemontaro Nakamura noticed variation in the level of the lava lake at the volcano of Kilauea, Hawaii, before and after the Great Kanto earthquake.

Lastly, let us consider the igneous rocks of Iwo-jima. This island is, curiously enough, composed of alkaline volcanic rock. Petersen[2] described the rock as an andesite but identified the minute crystals in the groundmass as sanidine. Thus the rock would be trachyte or trachyandesite in modern terminology. At the time of Petersen, it was a general tendency among petrologists to call volcanic rocks in the circum-Pacific regions andesite, and he was apparently affected by this idea of the petrographical province. The rock which Dr. Kikuchi[1] called a basalt is a crystalline trachyandesite, according to my sample. It may correspond to Petersen's augite-andesite (VI. Augitandesit). Whether there is glassy augite-andesite in it, as suggested by Dr. Wakimidzu, is not known. Dr. Kodzu named one of the rocks from Iwo-jima and oligoclase-andesite. The plagioclase phenocrysts, however, are andesine, as determined from the

indices of refraction alone, and not from the potash content. However, the plagioclases, according to their chemical composition, are oligoclase. Among 11 specimens of rocks and minerals described by Petersen, the writer could identify, under a microscope, a glassy augite-andesite, a pumiceous augite-andesite, crystalline augite-andesite, and feldspar crystals. Although the writer's study is not thorough enough to give a detailed description, in those rocks in which dark, glassy, amorphous portions and aggregates of minute crystals make a fluidal texture, minute prisms of feldspar in the groundmass have always lower indices of refraction than the balsam. The longer ones are evidently plagioclases close to albite and those among the interstices may be sanidine. Among phenocrysts, plagioclase is the most abundant and olivine and augite are present in nearly equal quantities. There are no rhombic pyroxenes. Magnetite and fairly large amounts of big crystals of apatite are present, too. In taking up each phenocryst, some of the plagioclases shows honeycomb-structure, more or less zonally built, and taking only indices of refraction into consideration, they show the constituent of lime-rich neutral plagioclase (Ab 52 An 48) and do not seem to be oligoclase, as previous authors stated.

Ogura, Rigakushi, made a study of a pumice of Shin-Iwo-jima

that was erupted to the northeast of South-Iwo-jima in 1941. The pumice is of practically the same composition as the above-described trachyandesite. The description by Ogura of the plagioclase as a neutral feldspar (Ab 63 An 37) is more of less close to the present one. The augite is light green and seems to be transitional to aegerine, showing a feeble pleochroism. The olivine is colorless and transparent, showing no marked corrosion. Wolff[9], in his "Vulkanismus", revised this determination to trachyte. It is a better name for the rock but trachyandesite may be still better.

Plagioclase crystals are strewn about on the beach and are called "Udzura-ishi". They have the some origin as the plagioclase in this glassy trachyandesite, and consist of two zones, inner and outer. The inner zone is a commonplace zonal plagioclase but the outer zone has a honeycomb structure, its spaces filled with glassy lava. Its composition, from the measurement of the indices of refraction, seems to be Ab 52 An 48 and Ab 60 An 40. Therefore, it can be expected that Ab 60 An 40 appears also in phenocrysts of the trachyandesite.

The phenocrysts contained in the trachyandesite from the base of Pipe-yama are the same as those in the above-described trachyandesite. However the groundmass is nearly holocrystalline and consists of soda-rich oligoclase (probably Ab 87 An 13)

Table of Analyses

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	$+H_2O$	$-H_2O$	TiO_2	P_2O_5	MnO	Total
1	59.30	16.61	1.51	5.02	1.55	3.16	5.63	4.41	0.95		1.11	0.44	0.21	99.90
2	61.18	18.16	5.97	1.76	0.79	3.55	5.51	2.75	1.72		-	-	-	101.49
3	59.89	17.23	9.96		0.77	2.96	6.21	2.92	0.61		-	-	-	100.53
4	60.55	17.29	2.72	3.22	1.12	3.22	5.37	4.36	0.53	0.21	0.85	0.28	0.19	99.91
5	60.82	16.63	2.15	3.46	1.79	3.35	5.62	4.21	ig. loss. 1.84		0.46	0.22	0.39	99.93

1. Dr.Kodzu: (Oligoclase-andesite) Class II, Order 5, Rang 2, (Monsonase), Subrang 4, (Akerose); Iwo-jima

2. Petersen: (Glassy augite-andesite); Iwo-jima

3. Petersen: (Augite-andesite pumice); Iwo-jima

4. Ushijima (Analyst); (Augite-syenite) Class II, Order 5, Rang 2, (Monsonase), Subrang 3, (Monsonase); Iwo-jima

5. Dr. Wakimidzu: (Augite-andesite) Class II, Order 5, Rang 2, (Monsonase), Subrang 4, (Akerose); Shin-Iwo-jima

and minor amounts of augite and the interstices are filled with sanidine (or orthoclase).

In addition to these volcanic rocks, there are pebbles of a macroscopically holocrystalline granitic rock among volcanic debris and terrace gravels, found all over the island. They are especially common on the northeastern coast. Big ones are elliptical with a diameter of over 30 cm. and small ones are blocks several centimeters in diameter. In the southwestern sandy waste some of them are dreikanters. Under the microscope, the rock consists of alkali-feldspar, in albite twins and more or less zonally built. (According to calculation, the composition is Or 31 Ab 56 An 13, or corresponding to a kind of anorthoclase by Alling[12]), with the minimum index of refraction 1.530 near the D line of Sodium.) There is light-green augite, aegirine-augite, olivine, and a minor amount of katophorite (?). The accessories are magnetite and much apatite, with the interstices, where present, filled with brown glass, in such a way as to suggest gravitational magmatic differentiation with sinking of crystals (as proposed by N. L. Bowen). For the time being the writer has called this rock augite-syenite; the analysis of it by Mr. Ushijima at the Geological Institute, Kyoto University, is given in the Table. Itsis surprising that this analysis should exactly agree with that made by Mr. Shimidzu

and corresponded by Dr. Kodzu to Mr. Washington as a rock from Iwo-jima, and also with the pumice erupted from the Shin-Iwo-jima in 1914, which was described by Dr. Wakimidzu. The Shin-Iwo-jima was erupted twice. Rocks of the first eruption in 1904 were studied by Dr. Wakimidzu and those of the second in 1914 by Mr. Ogura, Rigakushi. The former, Dr. Wakimidzu believed, resembled rocks of Iwo-jima, and the latter, Mr. Ogura proved by analysis, corresponded with those of Iwo-jima. Mr. Ogura observed two kinds of pyroxenes and described one as light grass green in thin section, and the other as deep green, with pleochroism hard to perceive. The writer suspects that the latter was an aegirine or aegerine-augite.

The writer regrets that his petrological observations have so far been too limited to say anything more definite. The fact that Iwo-jima and other active volcanoes nearabout erupt alkaline volcanic rocks, is worth our serious attention from the volcanological standpoint, and cannot be overlooked in connection with the geological studies on the Fuji volcanic chain.

The writer wishes for the one thousand of inhabitants on this forlorn island their welfare and wants to close this paper with gratitude to Mr. Aoki's family who always welcomes frequent visitors on arrival of all boats.

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no. 302

NUNTIA DE FILICIBUS JAPONENSIBUS (X)

By
Hirosi ITO

Journ. Jap. Bot. Vol. XIV,
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Translator's note:

[14] The author gives, in the item 36 of the "Nuntia de Filicibus" a list of ferns new to the flora of Micronesia

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*Translator's note:

Thomas Moore apparently made a mistake in reading or writing *Aspidium variolosum* of Wallich, and gave it in his Index Filicum as *A. variolatum*, from which his *Sagenia variolata* has been derived. Strictly speaking this should have been *S. variolosa*.

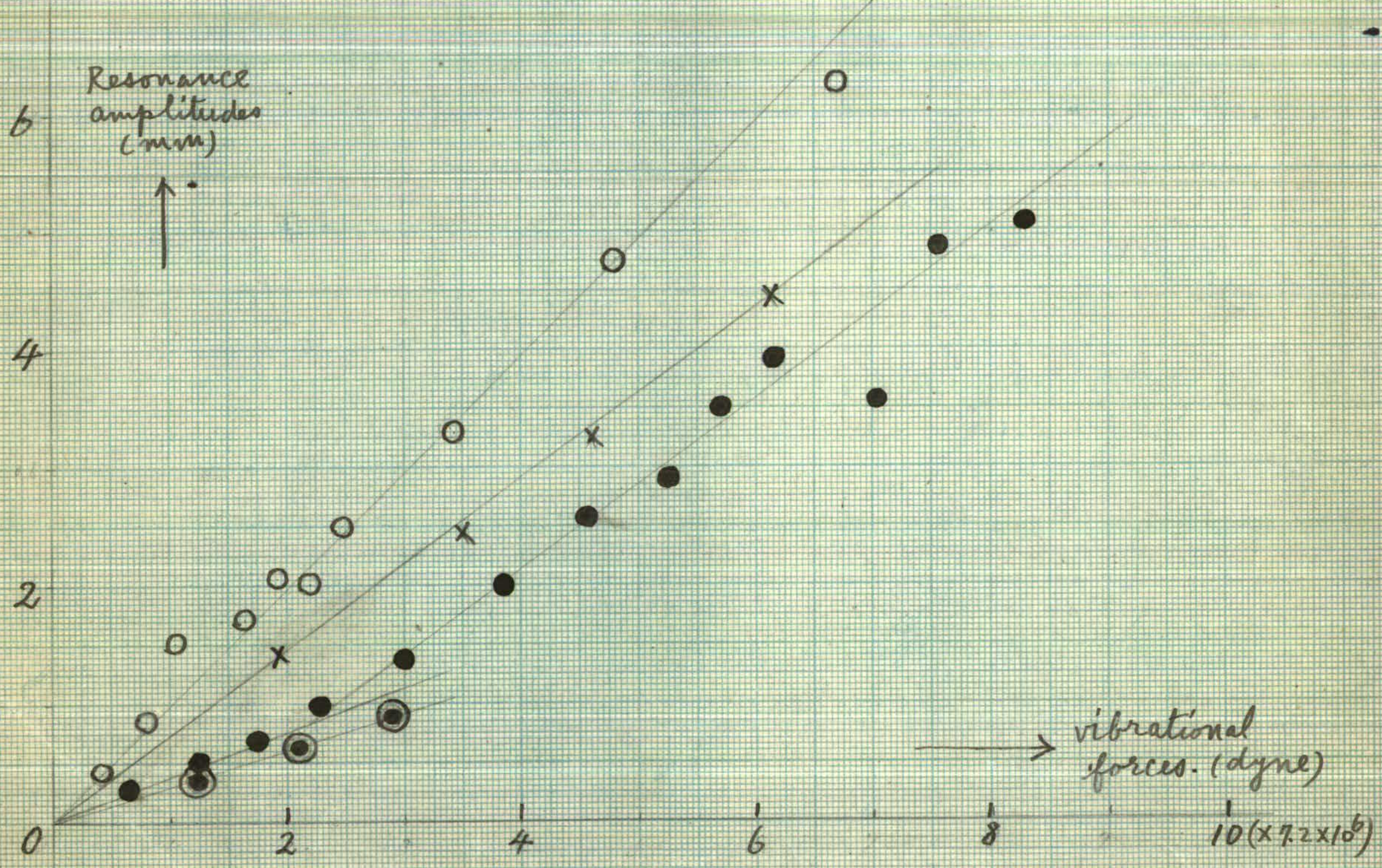
Resonance
amplitudes
(mm)
vibrational
forces. (dyne)
0
2
4
6
8
10 (×7.2×10^6)

Fig. 1.

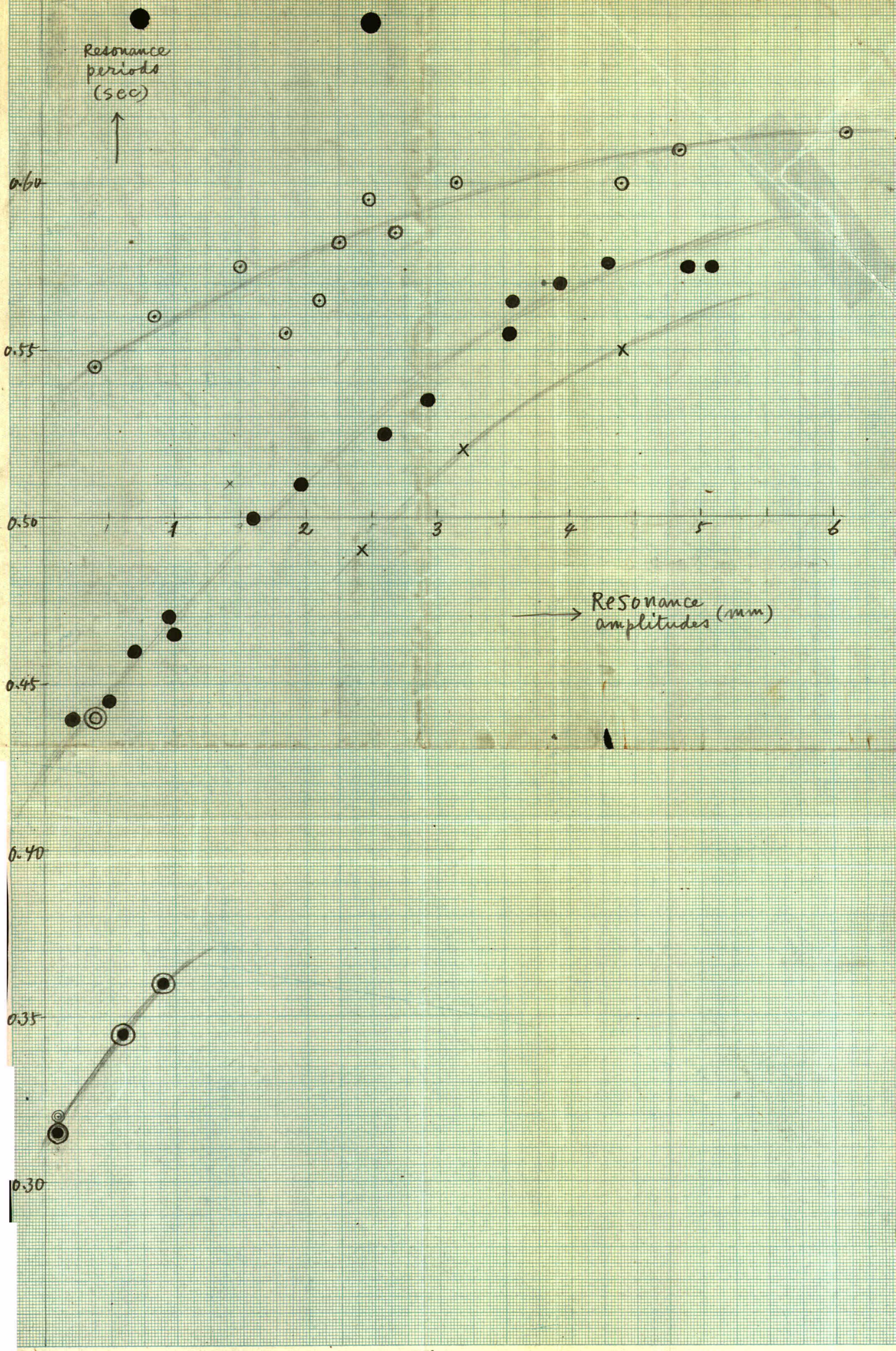
Resonance periods (sec)
0.60
0.55
0.50
0.45
0.40
0.35
0.30
1
2
3
4
5
6
Resonance amplitudes (mm)

Fig. 2.

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VIBRATION EXPERIMENTS WITH AN ACTUAL PRECAST REINFORCED CONCRETE CONSTRUCTION

**Read
at the symposium of the
Earthquake Research Institute**

on June 21, 1949

By

Kiyoshi KANAI

Earthquake Research Institute

Translated by K. Musya, Dec. 1949

(Unedited)

Pacific Geological Surveys
Military Geology Branch, U.S.G.S.
Tokyo, Japan

Vibration Experiments with an Actual *
Precast Reinforced Concrete Construction

(Read at the symposium of the Earthquake Research Institute on June 21, 1949.)

Kiyoshi KANAI

Earthquake Research Institute

The building that the writer conducted experiments was a two-story building of 3 meters x 4 meters, the column height of 3.41 meters and 3.26 meters, and the weight 7250 kilogrammes in the second floor and 7560 kilogrammes in the first floor respectively including the live load (1200, 1260 kilogrammes). The characteristic of the building is that pin joints are fitted to connect the column and beam, and the rigidity of the building is kept with brace struts. The brace struts are made of iron and the diameter is 13 millimeters in the first floor and 16 millimeters in the second floor respectively.

The experiments static as well as dynamic were conducted alternately. In the present paper dynamic experiments only are mentioned, which were conducted by the writer.

The vibration of the building was caused by a vibrator utilizing the centrifugal force installed in the central part of the roof. Four vibrators were used and the eccentric mass was 11.43 kilogrammes. Two sets each of which consists of two vibrators were

Figs. 1, 2, 3 with ribbon copy only

revolved inversely with a driving electro-motor. Thus the vertical component being canceled, the vibrational force of the horizontal component only was generated. By changing the eccentric distance from 0 to 11 centimeters the vibrational force was regulated. The vibration displacements magnified properly was recorded by applying the principle of lever to an arm attached to the pillar. The following four places were selected for the present experiments: between the ground and the second floor, the second floor, between the second floor and the roof, and the roof. A portable seismograph the period of which is 4 seconds was used on the second floor and the roof when the vibration amplitude was small.

Keeping the eccentric distance of the vibrator definite and by changing the vibration number in various ways, the amplitude in each vibration number was recorded. In such a way the so-called resonance curves were obtained. Such experiments were conducted in succession, and the relation between the vibrational force and the resonance period as well as the resonance amplitude was investigated.

The results obtained are shown in Fig. 1 and Fig. 2. Fig. 1 shows the relation between the vibrational force and the resonance amplitude, and Fig. 2 the relation between the resonance amplitude and the resonance period respectively.

(i) The first experiment (◎); Without the wall boards.

(ii) The second experiment (○); After hair-cracks were produced in the upper part of column by the static experiments, though the structure was the same as that shown in Fig. 1.

(iii) The third experiment (x); Iron brace struts covered with concrete.

(iv) The fourth experiment (⊙); With the wall boards.

(v) The fifth experiment (●); After hair cracks were produced by the static experiment.in the greater part of mortar filled up in the wall board pointing, the capital and the beam.

From Fig. 1 it is known that in the case of (ii), (iii) and (iv) the vibrational force and the resonance amplitude are in the lenear relation and apparently the Hook's law holds good of the whole building. In the case of (v) they are arranged on two straight lines, and as long as the vibrational force is small the same tendency as the case mentioned above is observed, and when the vibrational force reaches to a certain magnitude, the condition changes abruptly. After the condition changed, however, the vibrational force and the resonance amplitude are arranged on a straight line again.

In the caseoof (ii) the ratio of vibration displacement at

the four measuring points takes almost a definite value without any relation with the vibrational force (or the vibration displacement). Namely, even if the vibrational force increases and the vibration displacement becomes large, the mode of vibration of the whole building remains unchanged. The mode of vibration stated above and resonance period correspond with the results of theoretical study upon vibrations of buildings fitted with pin joints and brace struts. At least in the case of (ii) no change accompanying the increase of the amplitude was found in the elastic constant and the constructive conditions (mainly the connecting conditions of beams, pillars and brace struts). Nevertheless, it is shown in Fig. 2 that the resonance period becomes larger as the resonance amplitude increases. Assuming that the inertia mass wrought upon the capitals of the first and second floors is the mass of beams as well as floors and the live-load in the case of small amplitude, and the inertia mass is the mass of pillars, brace struts, etc. added to those mentioned above in the case of large amplitude, the ratio of the proper period becomes $\sqrt{6038(\mathrm{kg})/4820(\mathrm{kg})}$. The above value almost corresponds with the ratio of the resonance period of large and small amplitudes, viz., 0.615(sec)/0.54(sec) shown in Fig. 2.

In the case of (v) the above relation exists on the whole in the part of relatively small amplitude. In this case, if the wall boards are added to the mass of the vertical members, the inertia

mass increases from 4820 kilogrammes to 6740 kilogrammes and the ratio of the proper period becomes 1.18 times. Taking the ratio of the proper period from the starting point to the point where the straight line bends, 0.5 (sec)/0.43 (sec) is obtained, and the value approximatly corresponds with the result obtained based upon the intertia mass.

From the present experiments the phenomenon that the proper period becomes longer as the vibration amplitude of the building increases has been explained by the enertia mass affected to the capital, not taking the mass of the vertical members into consideration as long as the vibration is small and taking it into consideration when the vibration is large. The phenomenon mentioned above is quite different from the phenomenon that the period becomes longer owing to cracks produced in some part of the building.

It is known from O and X of Fig. 2 that when the damp of the iron brace struts covered with concrete increases, the resonance period becomes shorter and the resonance amplitude becomes very small at the same time. This nature has already been clarified by theoretical study[1].

It is known from Fig. 1 and Fig. 2 that the wall boards strengthen the rigidity of the building as long as no crack is produced in the wall boards while when cracks are produced in the

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1) K. Kanai, Bull. Earthq. Res. Inst., XVII (1939), 695-712.

pointings, the wall boards increase the mass more than the rigidity of the building.

In addition, the results of static **experiments** show that the bearing power of the building is more than two times of the intensity (0.2 g) in which the building is planned to be safe. However, from the results of the vibration experiments, it has been made clear that the destruction of the building seems to occur as soon as the acceleration of the ground exceeds 0.2 g.

no. 304

VIBRATION EXPERIMENTS WITH AN ACTUAL WOODEN SCHOOL BUILDING

Read
at the symposium of the
Earthquake Research Institute

on June 21, 1949

By

Kiyoshi KANAI

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Translated by K. Musya, Dec. 1949

(Unedited)

Pacific Geological Surveys
Military Geology Branch, U.S.G.S.
Tokyo, Japan

Vibration Experiments with an Actual Wooden School Building

(Read at the symposium of the Earthquake Research Institute on June 21, 1949)

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The vibration of a wooden schoolhouse built according to the Japanese Government standard was measured by the writer. The schoolhouse is a tile-roofed, two-story building. The column height is 3.5 meters, the width is 6 meters in the classroom and 2 meters in the corridor respectively, and the length is 10 meters. In both sides of the building there are partitions, and the part between the partitions is assigned to a classroom. Many brace struts are fitted. The brace struts of vertical members are 135 x 135 milimeters, and those of horizontal members 105 x 105 milimeters respectively. To connect the vertical members with horizontal ones many partial braces and metal fittings are fitted. Therefore, the school-building is a rigid construction much more than those in the past.

The vibration of the building was caused by a vibrator utilizing the centrifugal force, which was set in the middle part

of the second floor, and the vibration was measured with portable seismograph installed on the beam and on the second floor. Four vibrators were used, the eccentric mass of which was 11.43 kilograms. Two sets each of which consists of two vibrators were revolved inversely with a driving electro-motor. Thus the vertical component was canceled, and the vibrational force of the horizontal component only was generated. By changing the eccentric distance from 0 to 11 centimeters the vibrational force was regulated. The seismograph the period of which was 4 seconds was kept in the critical damping condition, and the geometrical magnitude was arranged so as to be 5.8 times on the beam and 9.6 times on the second floor.

Keeping the eccentric distance of the vibrator definite, and changing the number of revolution in various ways, the relation between the number of revolution and vibration amplitude was examined. From the resonance curve the relations between the vibrational force and resonance amplitude as well as resonance period were read. The results are shown in Table 1 and Table 2.

Table 1. Beam-direction (Frontage-direction)

Vibrational force (10^6 dyne)	Resonance period (sec)	Resonance amplitude (milimeter)		
		On the beam	On the second floor	On the beam / On the second floor
7.4	0.348	0.16	0.10	1.6
27.4	0.362	0.48	0.31	1.6
62.3	0.380	1.00	0.63	1.6
92.4	0.395	1.48	0.93	1.6
113.3	0.418	1.88	1.47	1.3

Table 2. Girder-direction (Depth-direction)

Vibrational force (10^6 dyne)	Resonance period (sec)	Resonance amplitude (milimeter)		
		On the beam	On the second floor	On the beam / On the second floor
9.7	0.305	0.26	0.24	1.1
35.4	0.319	0.48	0.45	1.1
80.2	0.335	—	0.85	—
129.0	0.334	1.25	1.10	1.1
135.0	0.383	1.43	1.10	1.3

Excluding from Table 1 the displacement on the second floor in the case of the vibrational force of 113.3 x 10^6 dyne, the amplitude is almost in proportion to the vibrational force. This shows that the elastic constant does not undergo change by the amplitude of vibration (or the vibrational force). The ratio of displacement 1.6 on the beam and on the second floor of the beam direction corresponds with the case of rigid connections at the floors and the base, and shows that the boundary conditions of the construction does not change by the amplitude of vibration, while the period of resonance becomes larger as the vibrational force (or the amplitude of resonance) increases. If it is assumed that the 8-ton dead load such as the roof truss, beams and floors exerts action as the inertia mass on the top of pillars of the first and second floors when the vibrational force is small, and the said 8-ton load and 2-ton mass of the vertical members exert action as the inertia when the vibrational force is large, the resonance period of the latter is

1.12 times of the former and it coincides with the result of measurement.

As to the girder direction in Table 2 the relation of period can be explained by the inertia mass stated above. In this case from the relation between the vibrational force and the resonance amplitude, the slight vibrational force suffices when the amplitude is small. And in this case the displacement on the beam does not differ much from that on the second floor. These phenomena may probably due to the stiffness of building and the vibrational force consumed to some extent to the bearing power of the ground. Accordingly, in this case the vibration of the building may probably be the resultant vibration of the usual elastic vibration and that with the base as the axis.

The phenomenon that the proper period becomes longer as the vibration amplitude of the building increases is very important regarding the destruction of buildings due to earthquake shocks. If a part of building is destroyed at the time of earthquakes, the proper period becomes longer as a matter of course. By the present investigation it has been explained that the proper period may change even if the condition of structure remains unchanged.

no. 305

no. 305

ON THE SOILS OF OUR SOUTH SEA ISLANDS
(First paper)

By
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in

Journal of the Science of Soil and Manure, Nippon

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Edited by A. C. Mason, 1 May 1951

Pacific Geological Surveys
Military Geology Branch, U.S.G.S.
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On the Soils of our South Sea Islands (First paper)

By
Yasuji MIYAKE and Ishio TAMACHI

Faculty of Agriculture, Hokkaido Imperial University

On Gasupan hill in central Palau proper and Tomil plain in Yap Island eluvial soils of andesite are observed. The aim of this paper is to determine the type of soil developed by the climate by examining the physical and chemical properties of the soil section.

The surface of these soils is dotted with a dwarf fern and innumerable concretions of bean-like sizes. The upper level of the Gasupan soil in Palau proper contains pieces of limonite as large as 4 cms thick and 250 square centimeters in area, below which is found Roterde [Ed. terra rosa, or red earth] about 35 cms thick. This layer is red, lustrous, and lacks humus. Below it is a Fleckenzon [Ed. mottled clay zone] consisting of beautiful red, blue, yellow, green, and violet specks. This zone is so thick that it is very difficult to measure it. This is shown by road cuts where the zone extends more than 10 meters deep. The clays in these two zones compose about 60% of the Roterde and 80% of the Fleckenzon.

An analysis by heated hydrochloric acid shows that the iron oxide contained in the Roterde amounts to 38% and decreases downward.

The alumina content is greatest near the boundary between Roterde and Fleckenzon and decreases gradually downward.

The manganese content in Roterde is far greater than that in the ordinary soil of temperate latitudes.

The molecular ratio of silicate to alumina is approximately two while that of silicate to sesqui oxide is approximately one.

Lime, magnesia, potash, and sodium are all so scarce as barely to be traceable.

Mattson's curves of neutralization of these two unsaturated soils in an application of dialysis to Roterde and Fleckenzon show a steep curve of very small obsorption power.

Ammonia exists in Roterde but not nitric acid.

The pH values of Roterde and Fleckenzon are both approximately 5.6.

From this it is seen that these soils belong to the laterites formed under a climate having high temperature and humidity.

no. 306

1948

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Members of the Prospecting Company

	Mitsui Co.	Yamada Co.
Members	M. Nagafuchi	G. Yanaka
	S. Tashiro	Y. Takiyama
	T. Tomiyasu	M. Ikui
	J. Nakaohara	E. Tsukada
	M. Matsuno	J. Oshima
	H. Shinohara	T. Ise
Assayer	R. Fujiwara	
	S. Serizawa	
Accountant	H. Nishiyama	

Period of Prospecting

From November, 1935

To November, 1936

1. Weather data, Palau 1926—1935

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average & total
Barometric pressure (in mm.)	Average	56.02	56.93	56.74	56.42	56.42	56.63	56.02	56.50	56.35	55.99	55.80	55.70	56.30
	High	60.6	61.5	60.7	60.6	60.8	59.9	59.5	60.1	60.0	60.8	59.8	60.2	61.5
	Low	48.2	52.0	52.5	39.8	37.9	52.7	51.2	52.8	51.8	49.5	48.6	47.9	37.9
Temp C°	Average	26.42	26.39	26.83	27.22	27.18	27.06	26.71	26.89	26.86	27.03	27.09	26.84	26.88
	Av.Max.	29.10	29.34	29.92	30.35	30.12	30.12	29.47	29.64	29.72	29.90	30.06	29.66	29.78
	Av. Min.	24.17	24.08	24.44	24.86	24.81	24.61	24.30	24.51	24.50	24.68	24.81	24.58	24.53
	Diff	4.93	5.25	5.49	5.49	5.32	5.51	5.17	5.14	5.22	5.21	5.25	5.09	5.26
	High	31.5	31.4	31.6	32.2	32.3	32.8	31.7	32.5	32.5	31.7	31.9	31.7	32.8
	Low	20.5	22.0	22.2	22.5	22.3	22.0	20.8	21.5	22.0	21.8	22.3	22.4	20.5
	Diff	11.0	9.4	9.4	9.7	10.0	10.8	10.9	11.0	10.5	9.9	9.6	9.3	12.3
Wind m.	Av.	2.85	2.71	2.64	2.19	1.77	1.38	2.06	2.06	1.91	2.08	1.92	2.18	2.15
	High	17.2	9.7	9.6	7.6	18.9	9.6	10.4	8.9	8.9	10.9	11.2	10.8	19.9
	Direction	N.NW	NE	N.NW	E	E	N.NW	W	W.SW	W.SW	W	N	N.NW	E
Rainfall mm.	Av.	180.37	183.22	227.85	219.54	199.66	191.79	157.08	182.50	168.51	184.42	119.46	194.43	2280.81
	Max.	229.40	209.41	262.85	242.95	225.50	229.25	201.37	242.43	208.00	251.85	220.80	240.60	2573.05
	Min	132.05	122.45	201.68	161.60	151.70	182.52	101.48	144.35	143.55	124.14	153.15	158.70	2155.75
Max.& Min. Rainfall (in mm.)	Av.	444.1	245.6	174.5	203.0	365.7	295.9	503.2	364.0	415.6	357.8	277.2	306.3	329.4
	Max.Mon.Amt.	787.0	435.9	247.9	324.9	656.5	396.1	833.3	602.2	569.1	729.3	608.4	485.1	4783.2
	Years	(32)	(30)	(34)	(29)	(27)	(28)	(27)	(26)	(34)	(31)	(32)	(28)	(29)
	Min.Mon.Amt.	206.6	104.2	100.4	96.4	233.1	201.2	274.6	145.3	290.1	167.1	118.8	92.0	3383.1
	Years	(30)	(26)	(31)	(26)	(35)	(29)	(34)	(30)	(27)	(30)	(27)	(35)	(30)
	Max.Daily Amt.	233.1	142.8	84.5	127.5	137.1	103.3	204.2	121.5	110.1	124.8	197.4	164.7	223.1

2. Population of Palau (June 31, 1936) End of June, 1936.

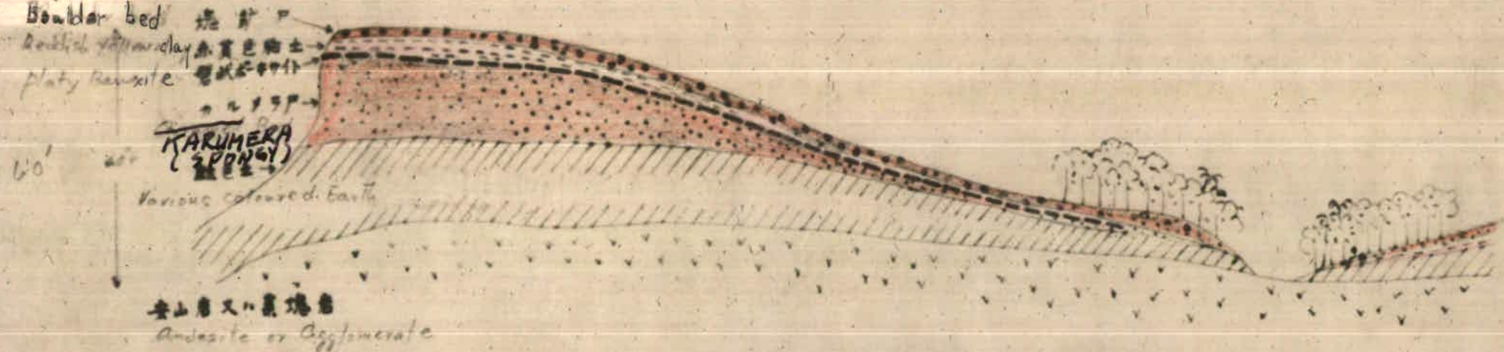
Island	Village	Japanese M	F	T	Native M	F	T
Palau, Proper	Ngarasmau	2		2	75	79	154
	Armonokui	226	189	415	141	133	274
	Gaspan (NGATPANG)				42	40	82
	Aimiriiki	17	2	19	117	107	224
	Airai	168	85	253	217	226	443
	Kaishal	148	101	249	166	163	329
	MarKyok (MELEKEIOK)	8	1	9	149	159	308
	Ogiwal	2		2	115	119	234
	Gorard	14	7	21	322	302	624
	Arkoron (AREKALONG)	8	3	11	320	308	628
	Total	593	388	981	1,664	1,636	3,300
Garkol					14	6	20
Kayangar		1		1	56	53	109
Colol (KORROR)		2,154	1,439	3,593	394	293	687
Arakabesan		473	144	617	96	78	174
Marakal		1,209	393	1,602	19	4	23
Peleliu		223	35	258	365	350	715
Angaur		231	193	424	479	203	682
Sonsol		19	2	21	74	82	156
Mery (MERIR)		1	0	1	13	13	26
Tobbi (Tobi)		9	4	13	84	88	172
Pool (PULO ANNA)					11	7	18
Total		4,320	2,210	6,530	1,605	1,177	2,782
Grand total		4,913	2,598	7,511	3,269	2,813	6,082

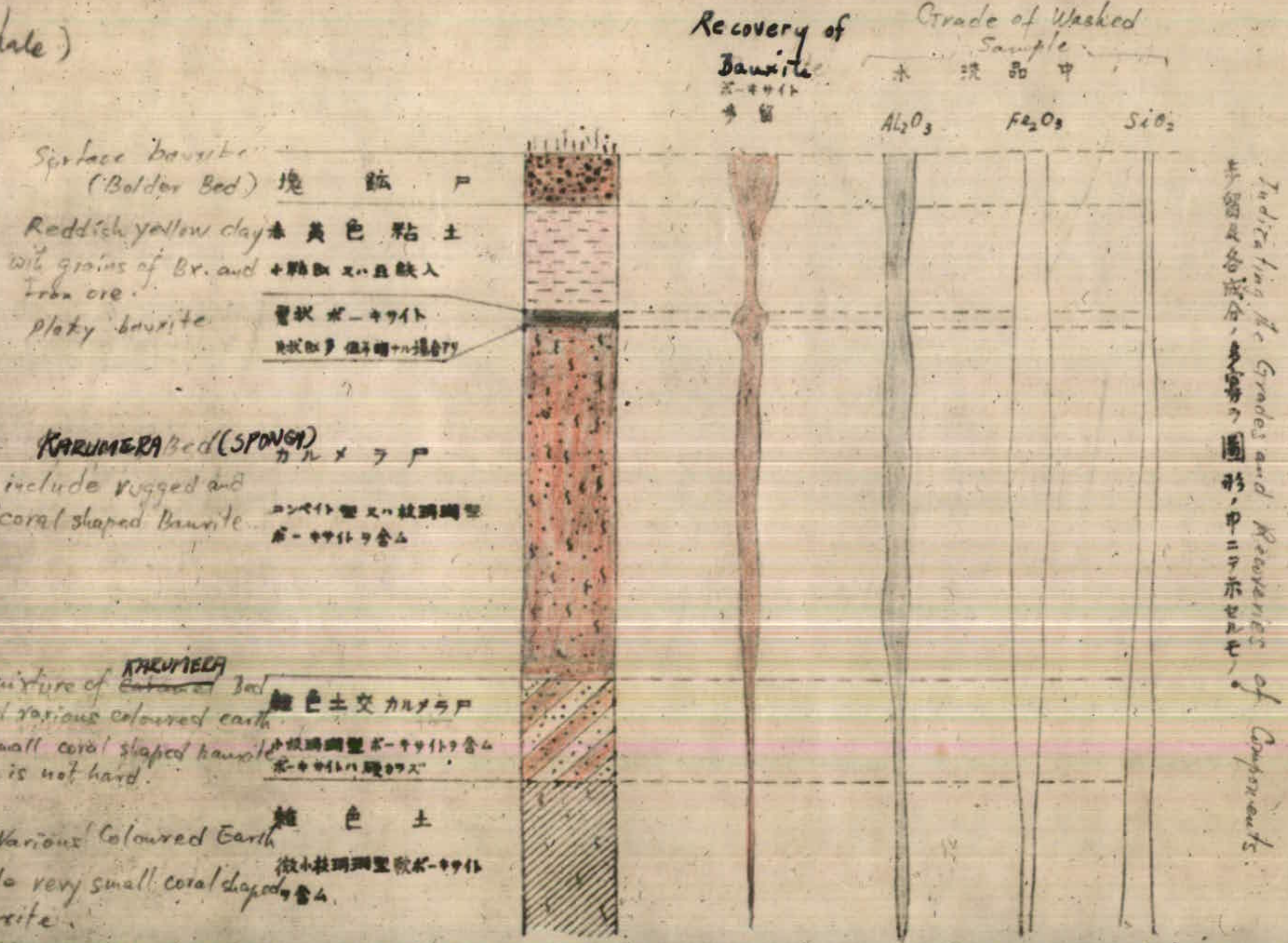
Note: Koreans included ~~to~~ with Jap. Chamuro is included ~~to~~ with islanders.

(3)

Section of Palau Bauxite Deposit & Diagram Showing the Character

パラオボーキサイト鑛床縦断面及性状表示圖





4. Measuring Data. Weight of Bauxite Bearing Earth of 1 ~~Ryu~~ cubic cubic-tsubo (~~6 m³~~ 6 shaku³) (1.818 cubic meter).

Sampled Place	Pit No	Depth	Character of Earth	Moisture	Recovery of Bauxite	Tons	Measured By
Arumasaka	N487K	1.0-4.5	~~Caramel~~ KARUMERA (SPONGY)	23.0%	12.0%	ton 10.8	Nakahara
-ditto-	N488L	3.2-6.2	~~Caramel~~ KARUMERA with boulders	24.0	36.0	11.2	"
Taihei mt.	454	36.0-39.0	Various coloured earth with yellow boulders		16.1	9.8	Yanaka
-ditto-	477		~~Caramel~~ KARUMERA		13.0	8.4	"
Maketuru Mt.	5519C	2.0-3.0	Yellowish brown earth		34.4	9.3	Shinohara
-ditto-	5544B	1.5-2.5	~~Caramelar~~ KARUMERA Red Earth		57.0	10.7	"
"	5507C	3.5-4.5	White-Purple-various coloured earth		10.0	9.2	"
"	5514C	6.0-2.0	~~Caramel~~ KARUMERA	25.4	45.7	10.8	"
"	5503B	2.0-3.0	~~Caramelar~~ KARUMERA Red Earth		26.3	10.3	"
"	5564C	3.0-4.0	Red-various coloured earth		20.8	9.4	"
Ngarasmau	5606B	1.5-2.5	~~Caramelar~~ KARUMERA Red Earth	25.4	25.6	10.9	"
"	5618B	1.0-2.0	Black-Various Colour~~er~~ed, Yellowish Brown Earth	37.0	11.1	9.2	"
"	5617B	1.5-2.5	Yellowish Brown Earth	30.0	28.0	10.2	"
"	5608B	1.5-2.5	Purple-Various Coloured Earth	37.0	11.0	8.9	"
"	5609B	1.0-2.0	~~Caramel~~ KARUMERA	17.0	68.9	9.1	"
				27.3		9.9	

5. Recovery Sheet of Districts

Base of the Calculation of Ore Reserve

By the Draft of Aimion Mine Office

	District	Average Recovery	Minimum Recovery	Remarks
1.	Aimion village(N.N)	25%	18%	
2.	Mt. Makelulu Taihei Mt.	30	23	Transported by Aerial Rope way.
3.	Arumaten	28	23	Nearest Road covers about 3Km, Transportation by land is necessary.
4.	Gurumisuka NW	26	23	Transportation by aerial rope way is necessary.
5.	Arumasaka village (Almaska)	26	22	Chiefly at ~~May~~ ~~SATSU~~ SATSUKI Plateau and forest.
6.	Garasumau. Airoru	33	27	Transportation by ferry is necessary
7.	Gasupang village (NGATPANG)	33	27	ditto
8.	Airai village	35	30	Long way transportation on land and ferry is necessary.
	Average	30	24	

Note: Numbers correspond to District numbers on Babelthuap small scale Mitsui map.

6. Ore Reserves of Bauxite, Palau

Primary

	SURFICIAL (SURFACE)				DEEP SEATED				
District	Area (Tsubo)	+8mesh MT	Size 8mesh (8mesh x50%)	Reserve Total Ton	Area	Average thickness (feet) (shaku)	Average recovery	Ore reserve	Total ore reserves
Garumisukang	321.300	121.296	60.648	181.944					181.944
Arumnogui (Amion)	370.580	167.360	83.680	251.040	72.500	6.8	26.3	215.600	466.640
II_3 Arumaten					5.900	8.8	25.7	22.300	22.300
Arumasaka (South)	162.600	61.600	30.800	92.400	13.250	7.6	28.4	47.100	139.500
(Middle)					9.450	2.5	29.8	13.100	13.100
(North)					11.000	6.4	32.0	33.400	33.400
Garasmau									
Irusumu (Makelulu)	594.750	430.486	215.243	645.729	86.800	7.6	32.8	384.400	1,030.129
West					6.300	6.9	36.0	23.200	23.200
East	228.800	86.770	43.385	130.155	11.350	4.8	32.7	28.900	159.055
Gakurao & upstream of water-fall	200.600	71.900	35.950	107.850	7.200	6.8	32.7	22.200	130.050
Marukyoku	1,159.070	109.740	54.870	164.610					164.610
Kaisharu	143.300	16.614	8.307	24.921					24.921
Airai & Gasakung	825.030	232.446	116.223	348.669					348.669
Aimiriki	128.700	33.998	16.999	50.997					50.997
Gaspang (NGATPANG)									
Old	253.856	92.959	46.480	139.439					139.439
New (include to Aimiriki)					4.850	9.6	31.3	23.900	23.900
Grand total	4.388.586	1,425.169	712.585	2,137.754	228.600			814.100	2,951.851

pt. 8

(Primary and Secondary)

7. Marginal + Workable Ore Reserve for Deep Seated Deposits

(Total reserve of bauxite excluding the content in various coloured earth)

District	Area (tsubo) sq yds	Thick ~~feet~~	Recovery	Ore Reserve MT
	tsubo	~~ft~~	%	
New Ngaspang	21,800 (86,000 / 17.8 a)	9.5 shaku	24.3	84.300
Garumisukan	28,110 (111,000 / 22.95)	9.9	21.3	99,900
Aimion	203,750 (804 000 / 166.)	7.5	20.3	530,400
Arumaten Head	19,000 (75,100 / 15.5)	7.9	19.1	47,900
Almaska village S	53.400 (210,500 / 43.5)	8.2	19.8	144,100
Almaska village Central	38.650 (152 500 / 31.6)	5.2	18.1	63,100
Almaska village N	130.640 (515,500 / 106.6)	7.4	22.2	354.300
E Irusumu Makeruru	317.940 (1,255,000 / 254.8)	7.5	25.8	1,061,100
Garasumau W	61,220 (241,800 / 50)	8.5	24.6	221,200
Garasumau E	57.680 (229,000 / 47.1)	6.1	24.7	138,300
Gakurao & upstream of waterfall	40,310 (159,200 / 33.7)	5.2	20.2	71,000
Deep Seated total	972,500 (3,840,000 / 794.75)	7.4	22.7	2,815,600
Surficial (surface) deposit				2,137,754
Grand total				4,953,354

Note:-
Figures in ( ) after area column are areas in sq. yds, (upper) and in acres, (lower) Computations by S.S.G.

Primary Actually mined

8. Ore Reserves ~~Less Mining Losses~~

	Surficial Deposits				Deep Seated Deposits				
District	Potential reserve (surfaced)	Re-covery	~~Recoverable~~ mined ore MT	Remarks	Potential reserve	Recovery	~~Recoverable~~ mined ore MT	Remakrs	Total
Garumisuka	181.944	70	127,361	Upstream of GarumisuKan is difficult for transportation. Recovery is low.					127,361
Arumonogui Aimio	251,040	90	225,936	Convenient for transportation	215,600	90	194,040	Transportation, (convenient.) Topography is gently-sloping & easy for mining.	419,976
Arumabang					22,300	80	17,840	Topography is gently sloping, but transportation is a little inconvenient.	17,840
Almaska S	92,400	70	64,680	Deposits are isolated ~~each other~~. North and Middle part are inconvenient for transportation by ferry.	47,100	80	37,680	Transportation is convenient by aerial rope-way.	102,360
C					13,100	50	6,550	The small deposit is isolated. Difficult for mining.	6,550
N					33,400	75	25,050	Transportation by ferry is necessary, the deposit is compact and easy for mining.	25,050
Garamasumau Irusumu	645,729	80	156,583	Located at high place, but topography is easy for mining.	384,400	85	326,740	Located at high place, but easy to transport by aerial rope-way.	843,323
Makerurur					23,200	80	18,560	A little inconvenient for transportation.	18,560
West									
East	130,155	70	91,109	Topography is steep, deposits are isolated ~~each other~~. Inconvenient for transportation.	28,900	70	20,230	Not convenient for transportation.	111,339
Gakurao & upstream of waterfall	107,850	60	64,710	Transportation is very inconvenient. Deposits are isolated.	22,200		-	Very inconvenient for transportation.	64,710
NW Dist Total	1,409,118		1,090,379		790,200		646,690		1,737,069
Ngatpang Old	139,439	50	69,720	At south part deposits are isolated and transportation is inconvenient. At north part conditions are a little better.					69,720
New					23,900	60	14,340	Transportation by ferry and rope way is necessary. Deposits are isolated.	14,340
Marukyoku	164,610			Deposits are thin. Ferry transportation is necessary. Cannot work for sometime.					
Kaisharu	24,921			-ditto-					
Airai	199,887	90	179,878	Convenient for transportation. Easy for mining.					179,898
Gasakang	148,782	50	74,391	Mountaneous area, inconvenient for transportation					74,391
Aimiriiki	50,997			Ferry transportation is necessary. Deposits are isolated. Cannot work for sometime.					
S.E Total	728,636		324,009		23,900		14,340		338,349
Total	2,137,754		1,414,388		814,100		661,030		2,075,418

8a

Ore Reserve, Palau, Proper. Calculated on the end of Feb.1936.

Districts	Area of Deposit	Ore Reserve	Ore, Ton Per Tsubo	Estimated Ore Reserve for District	Remarks
Ngatpang	253,856	92,959	0.368		Deposits
GarumisuKan	183,300	67,996	0.370		Deposits were discovered ~~at the~~ in upstream of GarmisKan R., but inconvinient for transportation and mining.
Aimoion	319,880	123,360	0.388	200,000	Takaranomori deposit should be added. If ~~caramel~~ KARUMERA (SPONGY) bed of this deposit is workable, ore reserve will be increased very much. Similar ~~caramel~~ KARUMERA bed was discovered at ~~Marmatten.~~ ARUMATEN.
Arumasaka	104,000	28,100	0.270		~~May field~~ SATSUKI deposit was discovered and the ore reserve was ~~added~~ double ~~amount~~. When caramel bed is workable the reserve will be ~~added for more.~~ further increased.
Garasman, W.	586,500	417,244	0.710	500,000	~~Caramel~~ KARUMERA bed was discovered at Taihei Mt. field.
Garasmau, E.	228,800	86,770	0.380		
Gakurau	162,200	54,000	0.333		
Marukyoku	1,159,070	109,740	0.095		
Kaisharu	143,300	16,614	0.116		
Airai, GasaKan	825,030	232,446	0.282	180,000	
Total	3,965,936	1,229,229	0.310		

Note; As described ~~at~~ in remarks column, several new deposits were discovered after the prospecting, and the ore reserve was increased a little. If ~~caramel~~ KARUMERA bed is recognized as workable after washing-test, immense ore reserve will be added at west coast region.

9. Summarized Assay Report of Samples of Main Deposits of Bauxite, Palau.

Av. Grade Washed Bauxite.

District	No. Analyses	No. Samples with Al_2O_3 >45%	Workable Ore Reserve Al_2O_3 >45 %	AVERAGE GRADE (Mathematical Average) Including lowgrade ore Al_2O_3 Av. of column 2	Fe2O3	SiO2	Ore grade >45 % Al_2O_3 Av. of column 3	Fe2O3	SiO2
Marukyoku	35	27	0.77	46.61	16.54	6.28	50.18	12.06	6.15
Kaisharu				* 42.61			* 47.10		
Gasiakan	16	16	1.00	51.84 * 49.72	12.25	3.54	51.84 * 49.72	12.25	3.54
Airai	10	9	0.90	52.67 * 49.39	10.28	5.46	54.27 * 51.54	9.64	4.55
Aimiriiki	12	5	0.414	40.58 * 37.46	25.90	5.20	51.16 * 48.92	13.50	3.73
Ngatpang	135	100	0.74	47.35 * 44.54	17.02	4.68	50.69 * 48.30	13.59	3.98
Garumisukan	10	10	1.00	51.97 * 49.82	12.40	3.59	51.97 * 49.82	12.40	3.59
Amion	28	18	0.642	46.80 * 45.85	21.38	1.59	50.53 * 49.62	16.62	1.51
Almaska	25	24	0.96	50.56 * 49.70	16.18	1.43	50.85 * 50.03	15.78	1.36
Garasumau W	104	89	0.885	49.02 * 47.95	18.01	1.79	51.03 * 49.92	15.33	1.85
Garasumau E	23	19	0.825	49.80 * 48.16	16.50	2.74	51.34 * 49.65	14.48	2.81
Gakurao	7	7	1.00	50.00 * 49.14	16.16	1.44	50.00 49.14	16.16	1.44
Total & averages	405	324	0.84	49.16 * 47.08	17.23	3.46	51.25 49.39	14.17	3.10

When - 49 % are taken.... 0.64

Note: (*) marked are showing %-age of available alumina.

Available Alumina = Total Alumina -(SiO_2 x 0.6)

10. Ore Reserve and Grade of Bauxite, Palau (incomplete) On the end of Sept, 1936.

District		SURFACE DEPOSITS Ore Reserve (in m tons) Ton	No.	Assay Al_2O_3 %	Assay Fe_2O_3 %	Assay SiO_2 %	DEEP SEATED DEPOSIT Ore Reserve (in m Ton)	No.	Assay Al_2O_3 %	Assay Fe_2O_3 %	Assay SiO_2 %
Ngatpang											
old		139,439	100	50.69	13.59	3.98					
new							23.900	4	49.9	16.6	1.8
Garumiskang		181,944	10	51.97	12.40	3.59					
Arumonogui)											
Aimon)		251,040	18	50.53	16.62	1.51	215,600	27	46.1	20.1	3.3
Arumatang)							22,300	19	53.4	14.4	1.7
Arumasaka	S)	92,400	24	50.85	15.78	1.36	47,100	24	50.0	16.6	2.7
	M)						13,100	5	49.1	17.0	1.9
	N)						33,400	8	47.0	20.2	1.6
Garasumau Erusumu Makekuru		645,729	89	51.03	15.33	1.85	384,400	37	48.0	19.5	3.3
	W						23,200	1	40.7	16.5	2.8
	E	130,155	19	51.34	14.48	2.81	28,900	4	46.4	19.5	3.3
Gakurao & upstream of water-fall		107,850	7	50.00	16.16	1.44	22,200				
Marukyoku		164,610	27	50.18	12.06	6.15					
Kaisharu		24.921									
Aimiriiki		Not workable	5	51.16	13.50	3.73					
Airai		348,669	9	54.27	9.64	4.55					
Gasakang			16	51.84	12.25	3.54					
Total & Av.		2,086,757	324	51.25	14.17	3.10	814,100	129	48.8	18.1	2.7

Note; For Surface deposit, average of only Al_2O_3 > 45%

For deep seated deposit, high recovery pits of proved ore reserve only were taken.

11. Washing Test of Earthy Ore at Palau, by Surface Conditions.

Surface Condition		+1/8"	mesh 1/8"-40	mesh 40-100	Recovery mesh +40	Recovery mesh +100	mesh 40/ /1/8"	No. of Sample
Within deposit	Moistened earth	34.5	16.9	4.6	51.6	56.0		8
	Dry earth	43.2	21.1	5.7	64.3	70.0	1.48	
Forest near deposit	Moistened earth	16.2	9.2	2.4	25.5	27.8		4
	Dry earth	10.3	11.5	3.0	11.8	34.8	1.56	
Apart from deposit	Moistened earth	7.2	5.5	1.9	12.8	14.7		
	Dry earth	9.0	6.6	2.4	16.0	18.4	1.70	4

Note: Recovery for moistened earth ~~were~~ was calculated from the recovery of dried earth assuming the moisture is 20%).

Assay of Earth Containing Ore at Main Deposits.

Kind of Ore	Al_2O_3 %	Fe_2O_3 %	SiO_2 %	No. of samples
Without screening, contains lumps.	44.14 1) *33.35 2)	15.12	9.66	32
Excluded lumps by 1/8" screen.	41.00 1) *37.02 2)	23.70	6.44	48
Excluded grains - 14 mesh.	38.62 1) *35.13 2)	24.42	5.83	4

Result:- 1) Larger sized ore contains more Al_2O_3, less Fe_2O_3, more SiO_2.
2)*More available alumina is contained at coarser grains.

Washing Recovery and Assay Results of Ore Bearing Earth at Main Bauxite Deposits, Palau.

(No. of Sample 10).

Size	Washing Recovery	Assay Results Al_2O_3	Fe_2O_3	SiO_2
+ 8mesh	* 32.25 (43.00)	53.0	12.0	2.52
8mesh - 40mesh	* 19.13 (25.5)	49.0	17.0	2.69
40mesh - 100 mesh	* 5.7 (7.6)	48.7	14.0	4.02
-100mesh	* 17.23 (23.0)	34.2	17.8	11.60
Average		46.8	13.6	4.63
+ 40mesh average	* 56.38 (68.5)	51.4	13.8	2.58

Note;

*) marked are the recovery for moistened earth.
Moisture is assumed 25%.

12. Comparison of various washing methods, tested for mixed ore samples of Airai Deposit.

(I) Sample, 303D. S-slope of west part of Germerschs. Average from surface to 126cm deep., Moisture 30%.

Washing method	Weight before washing include moisture	Weight after washing dried	Washing Recovery: Wet sample	Washing Recovery: Dry sample	Assay: No.	Assay: Al_2O_3 %	Assay: Fe_2O_3 %	Assay: SiO_2 %
Unwashed earth	30%					32.2	27.0	16.6
Left 5min. and washed 15 times	gr 535.4	gr 146.0	% 27.3	% 39.0	513	36.72	25.5	9.6
" " "Rice-washing" method	392.7	105.0	26.7	38.2	511	38.34	24.0	9.4
Heavy Rice washing method	548.9	121.5	22.1	31.6	512	40.77	21.2	7.4
100 mesh screen is used	688.0	155.5	22.6	32.3	514	42.84	19.2	8.6
(II) Sample 304E, Same location to (D.	~~A~~Average from surface to 190cm deep. Including 14cm of surface lamp ore bed.							
Left 5min, washed 15 times.	gr 485.5	gr 100.5	% 20.8	30.0	517	% 27.63	34.6	12.6
Rice washing method	480.0	82.0	17.1	24.7	515	29.70	32.2	8.7
Heavy rice washing method	554.5	90.7	16.3	23.7	516	35.10	31.3	8.7
100 mesh screen is used	444.0	67.0	15.1	21.9	510	38.16	25.1	7.5

Conclusion

a) By every washing method, grade is increased remarkabl~~l~~y when fi~~fes~~ne grains are seperated.

b) Increase of grade is max. when 100 mesh screen is used, and min. when the ore was left 5min.

c) Recovery is contrary to the above.

d) The ~~insufficient~~ unsatisfactory results of both washing test of I and II for grade are due to the too deep mining of laterite under lump ore bed, and it contains comparatively more silicate, magnetite and hydrated iron oxide where concentration of Al_2O_3 is not enough.

e) If to be treated by through washing, the grade of ~~shipping~~ ore should be raised high in order to meet the expenses involved. ~~payed only for high graded ore.~~
It is more profitable to ~~treat less high graded ore than more low graded ore.~~ produce small amount of high grade ore than to produce large amount of low grade ore.

Summarized Analysis of Clay or mud outside of ore deposit.
(soil)

Surface condition	District	Al_2O_3	Fe_2O_3	SiO_2	$\frac{Al_2O_3}{Fe_2O_3}$	$\frac{Al_2O_3}{SiO_2}$	No. samples
		%	%	%			
Forest	Murukyoku	29.35	14.61	32.10	2.01	0.91	6
	Airai	30.48	14.01	27.56	2.18	1.19	5
	Aimiriiki	29.07	13.97	29.90	2.08	0.97	7
	Ngatpang	30.73	17.66	24.43	1.74	1.26	8
	Garumisukan	30.29	13.55	28.28	2.24	1.07	6
	Av.	29.99	14.94	28.29	2.01	1.06	32
Grassland		28.69	12.97	32.08	2.21	0.89	8

12b

Soils having $SiO_2 < 20\%$ and its washed product
(Includes ore)

Mostly from A[illegible]monogui village.

SiO_2 in soil	No.		Washing recovery	Al_2O_3	Fe_2O_3	SiO_2
0 - 5 %	21	Soil		40.8	24.35	2.72
		Washed ore		45.6	20.7	1.9
		Available Al_2O_3		44.46		
5.1 - 10	16	Soil		37.93	23.38	7.19
		Washed ore		44.9	19.9	3.6
		Available Al_2O_3		47.74		
10.1 - 15	25	Soil		35.8	20.65	12.7
		Washed ore		46.2	17.10	6.08
		Available Al_2O_3		42.55		
15.1 - 20	22	Soil		34.3	17.9	18.1
		Washed ore		44.9	15.2	10.2
		Available Al_2O_3		38.79		
10.1 - 20	47	Soil		35.08	19.35	15.2
		Washed ore		45.6	16.2	8.0
		Available Al_2O_3		40.79		
0 - 20	84	Soil	34 %	37.0	21.4	10.6
		Washed ore	$\frac{\text{dry}}{\text{dry}}$	45.5	18.01	5.6
		Available Al_2O_3	$\frac{\text{dry}}{\text{wet}}$ 25.5%	42.1		
			(assuming moisture is 25%)			
Av. difference of soil & washed product				8.5	3.39	5.0
% of diff. of grade to grade of original soil				23.0	15.84	47.17

13. Washing recovery by depth(Investigation by deep pits at NGATPANG Gaspan District)

Dry
wet

No. of pit (deep)	SURFACE Surficial deposits %	Down to 50 cm %	50 cm-1m %	1m - 2m %	> 2m %
S300		3.7	3.7	4.0	9.4
S301		20.7	25.4	21.3	12.4
S302		21.9	21.9	31.3	
S303		5.9	5.9	6.5	6.4
S307	32.2	4.8	7.6	16.9	
S308	46.6	14.6	6.5	1.9	
S309	61.0	14.8	14.8	8.3	
S310		1.6	1.0		
Ō-~~L~~102	25.0	11.8	11.8	9.2	
Ō-~~L~~103		12.6	11.6	11.6	11.2
Ō ~~L~~104	54.7	27.2	27.2	22.2	
S311	66.5	67.4	18.4	1.4	9.9
S312	66.0	17.3	17.3	5.6	5.2
S313	21.8	4.1	7.4		
S314	22.0	6.7	6.7	3.1	
S315	20.0	19.9	15.6	15.6	15.9
S316	54.2	5.7	10.9	11.9	
S317	53.6	8.2	8.2	14.4	13.4
S318	78.6	49.0	28.9	11.9	11.5
S319		7.1			
S320	73.2	10.6	4.8		
S321	45.2	33.3	33.3	36.8	15.2
Ō-~~L~~105	25.0	27.6	35.7	6.7	
Ō-~~L~~106		14.6	13.5	11.3	
Ō-~~L~~107	39.2	9.8	8.6		
S322	67.6	35.3	35.3	13.8	
S323	55.4	32.3	13.7	16.3	
S324	62.8	13.8	13.8	21.0	9.7
S325	53.5	15.3			
S328	52.3	6.3	6.3	8.7	
S329	52.2	5.5	5.5	13.8	21.4
Av. Recovery	49.1	16.8	16.3	13.1	11.8

Stream Gauging Data at Garumuskan R. (p.m. 1.00 to p.m. 2.30. Sept. 21st, 1936)

ガルミスカン川水量調　昭和十一年九月廿一日午後一時～二時半

explanation on back

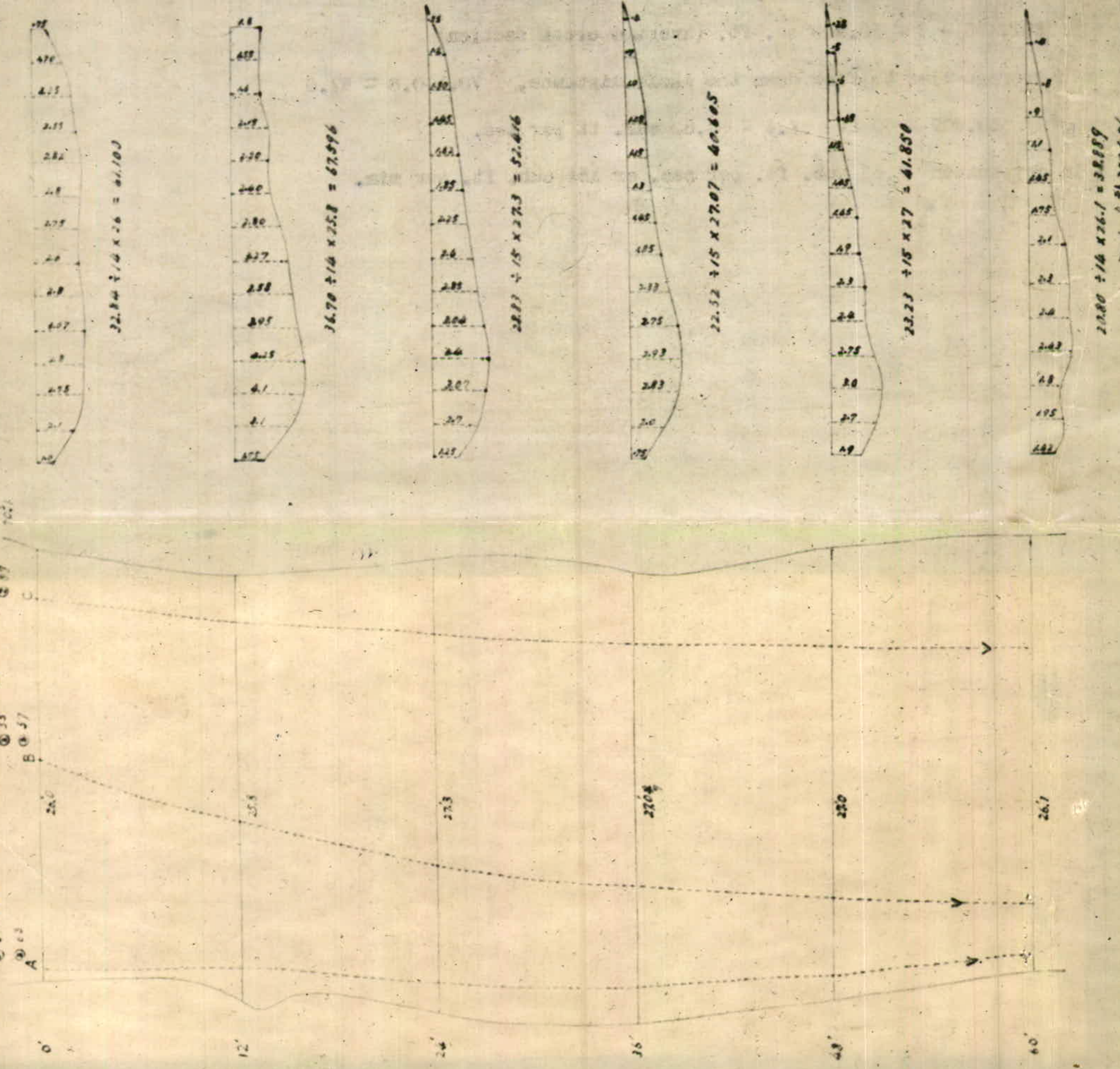
302.456 ÷ 6 = 50.409

全断面ヲ流ルル平均時間ハ 70.1 + 0.5 = 87.6

50.409 × 60' ÷ 87.6 = 34.52 per second

毎秒ノ流水量 2.88 per Second

123 per minute



Stream Guaging Data at Garumiskan River

(p.m. 1.30 to p.m. 2.30, Sept. 21st, 1936)

Up to about one mile downstream ~~to~~ FROM the observation point, high tide comes up.

Wind was considerably strong against the stream when the guaging was done.

For several days, there was severe rains. Four or five times ~~skated~~ it rained last night, today is good weather though it "~~skated~~ rained" in the morning.

Generally it is rain season recently, and it is reasonable ~~to take 1/12 of present water volume at the most dry season.~~ to assume that the volume of water during most dry season is 1/12 of the present volume.

302.456 ÷ 6 = 50.409 ~~sq. ft.~~ sf. (average cross section)

Average time to flow down the whole distance, 70.1÷0.8 = 87.6s

50.409 X 60 ft ÷ 87.6 = 34.52 ~~cub. ft~~ cf per sec.

1 in dry season 2.88 ~~cub. ft.~~ cf. per sec. or 173 ~~cub. ft.~~ cf. per min.

14 Stream Guaging Data at Garumiskan R.

(p.m. 1.30 to p.m. 2.30, Sept. 21st 1936)

Up to about one mile downstream to the observation point, high tide comes up. Wind was considerably strong against the stream when the guaging was done. For several days there was severe rains. Four or five times skaled last night, To-day is good weather though it skaled in the morning.

Generally it is rain season recently, and it is reasonable to take 1/12 of present water volume at the most dry season.

302.456 ÷ 6 = 50.409 sq. ft. (average cross section)

Average time to flow down the whole distance, 70.1 ÷ 0.8 = 87.6 sec.

50.409 x 60 ft ÷ 87.6 = 34.52 cub ft per sec.

1 in dry season 2.88 cub ft per sec or 173 cub ft per min.

(Atesh)
Stream guaging data at Atet River, Garesmau

(About one mile upstream from the mouth of the River. Tide comes up at high tide)

Only once was " skaled" in fifteen days before the measuring. The weather is fine.

Generally, it is the rainy season, and it is reasonable to take 90 o/o from the quantity of rainy season ~~en~~ for dry season.

(Measured a. m. 9.00, Sept. 11th 1936. Weather was shining. Low tide at a. m. 10.40.

Water level 0.70)

B.

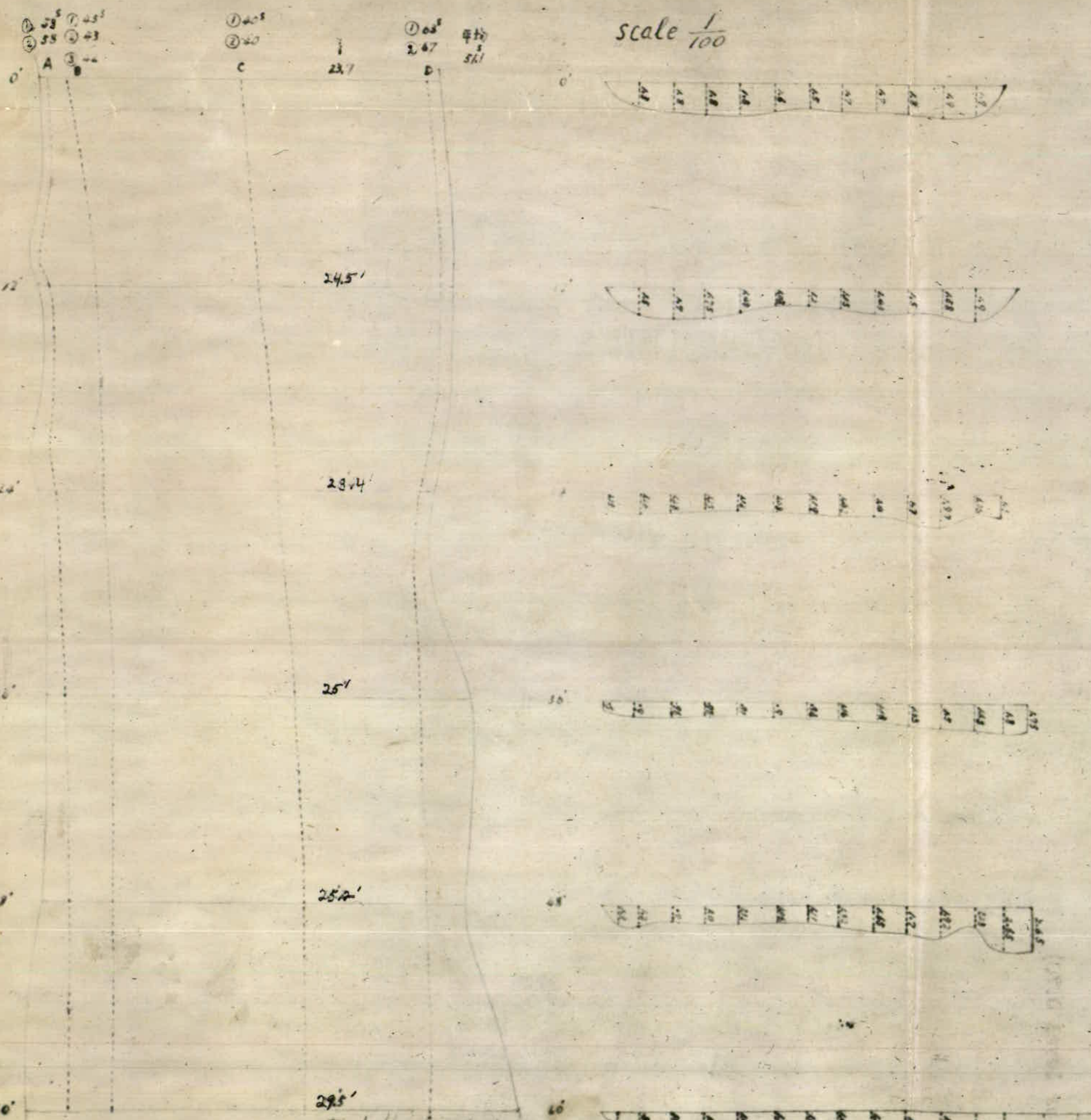
ガラスマオ　アテツ川水量調

（川口ヨリ東約一哩点・満潮時ニハ水位上ル）

昭和十二年九月十一日午前九時測定（天気晴・干潮ハ午前十時四十分・水位〇・七米）

備考　測定時ヨリ前十五日間ニ只一時スコールアリタルノミニテ大体天気良好ナリ、但シ一般的ニ雨期ナルタメ・旱魃時期ニハ此水量ノ約一割ト見ルヲ妥当トスベシ。

scale $\frac{1}{100}$



1.3 × 23.7 = 30,810

1.25 × 24.5 = 30,625

1.34 × 23.4 = 31,356

1.18 × 25 = 30,600

1.39 × 25.2 = 35,028

1.74 × 29.5 = 51,330

計 Total 209,749

209.749 ÷ 6 = 34,958 全距離ヲ流ルル平均時間ハ 31.1 ÷ 0.3 = 63.9 (av. time to flow down the distance)

34.958 × 60 ÷ 63.9 = 32.82 per second

水量 約33個 (Kō) or 2000 per minute (water quantity approx)

16

Stream guaging Data at Nedeshu~~ku~~ River, Aimion

By Matsuno, p. m. 3.00. Septembe r 21st, 1936,

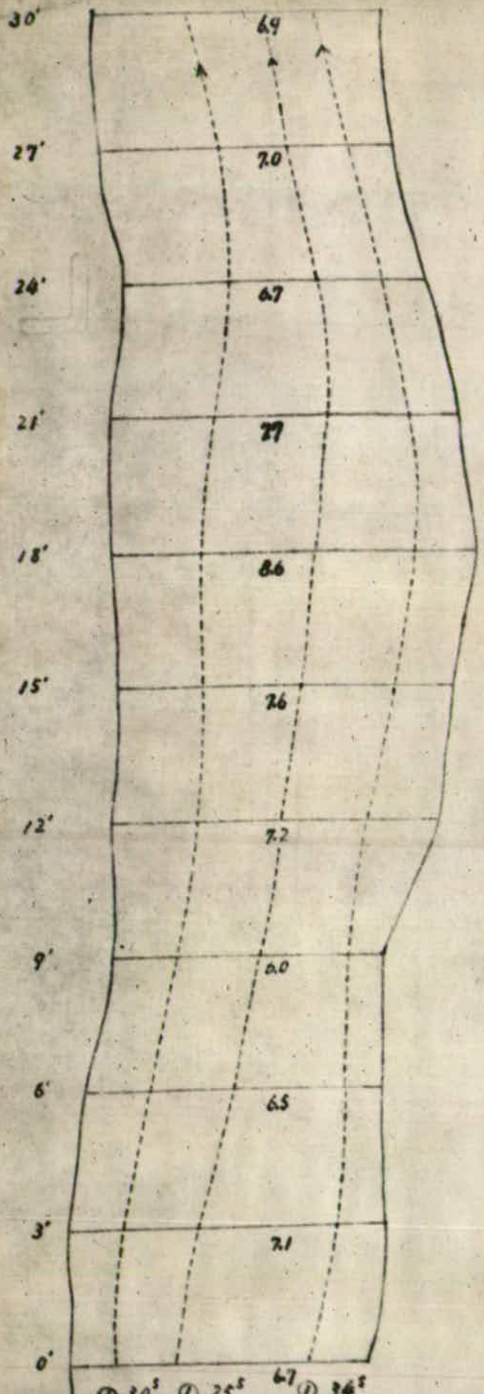
"~~S kaled~~" rained in the morning. Many times rained on these days. Generally, it is rainy season, and it is reasonable to ~~take 1/12 of the water quantity in dry season~~ assume that the volume of water during dry season is 1/12 of the present volume. Tide is not coming up at high tide time.

explanation on reverse side

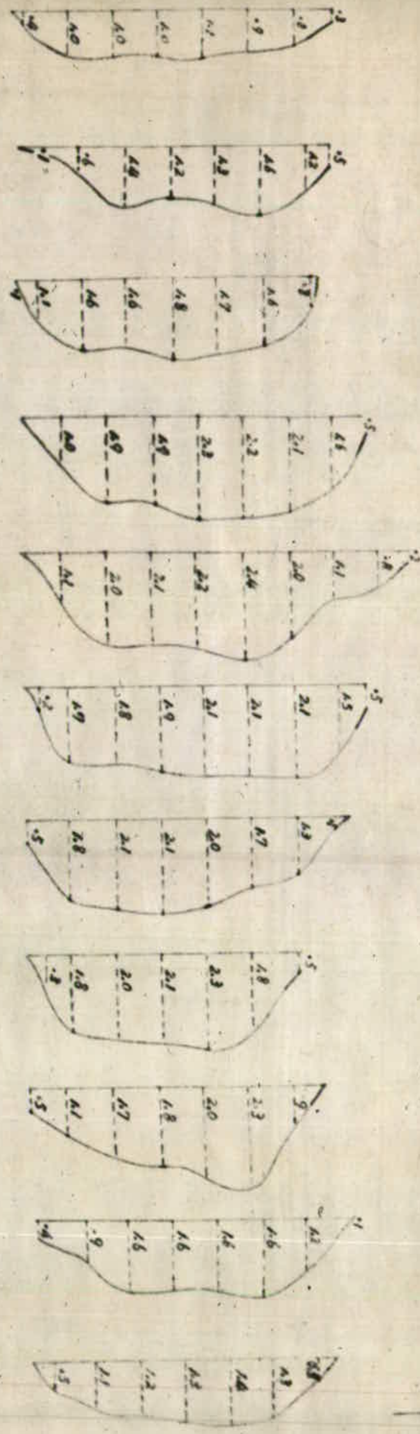
ネデシュール川水量調

昭和十一年九月廿一日 午后三時測定（松野）

午前中スコール有、両三日以来雨多シ。
一般ニ雨期ナルヲ以テ旱魃期ニハ此水量ノ十二分ノ一ト見ルヲ至当トスベシ。
高潮時モ水位上ラズ。



① 30^5 ① 25^5 ① 34^5
② 33 ② 26 ② 35 平均 31^5
③ 34 ③ 26 ③ 37



6.5 ÷ 8 = .8	× 6.9	= 5.62
7.9 ÷ 8 = 1.0	× 7.0	= 7.00
10.3 ÷ 8 = 1.3	× 6.7	= 8.81
13.5 ÷ 9 = 1.5	× 7.7	= 11.55
13.9 ÷ 10 = 1.4	× 8.6	= 12.04
13.9 ÷ 9 = 1.5	× 7.6	= 11.40
11.6 ÷ 8 = 1.4	× 7.2	= 10.08
10.8 ÷ 7 = 1.5	× 6.0	= 9.00
10.3 ÷ 8 = 1.3	× 6.5	= 8.45
9.0 ÷ 8 = 1.1	× 7.1	= 7.81
7.3 ÷ 8 = .9	× 6.7	= 6.03

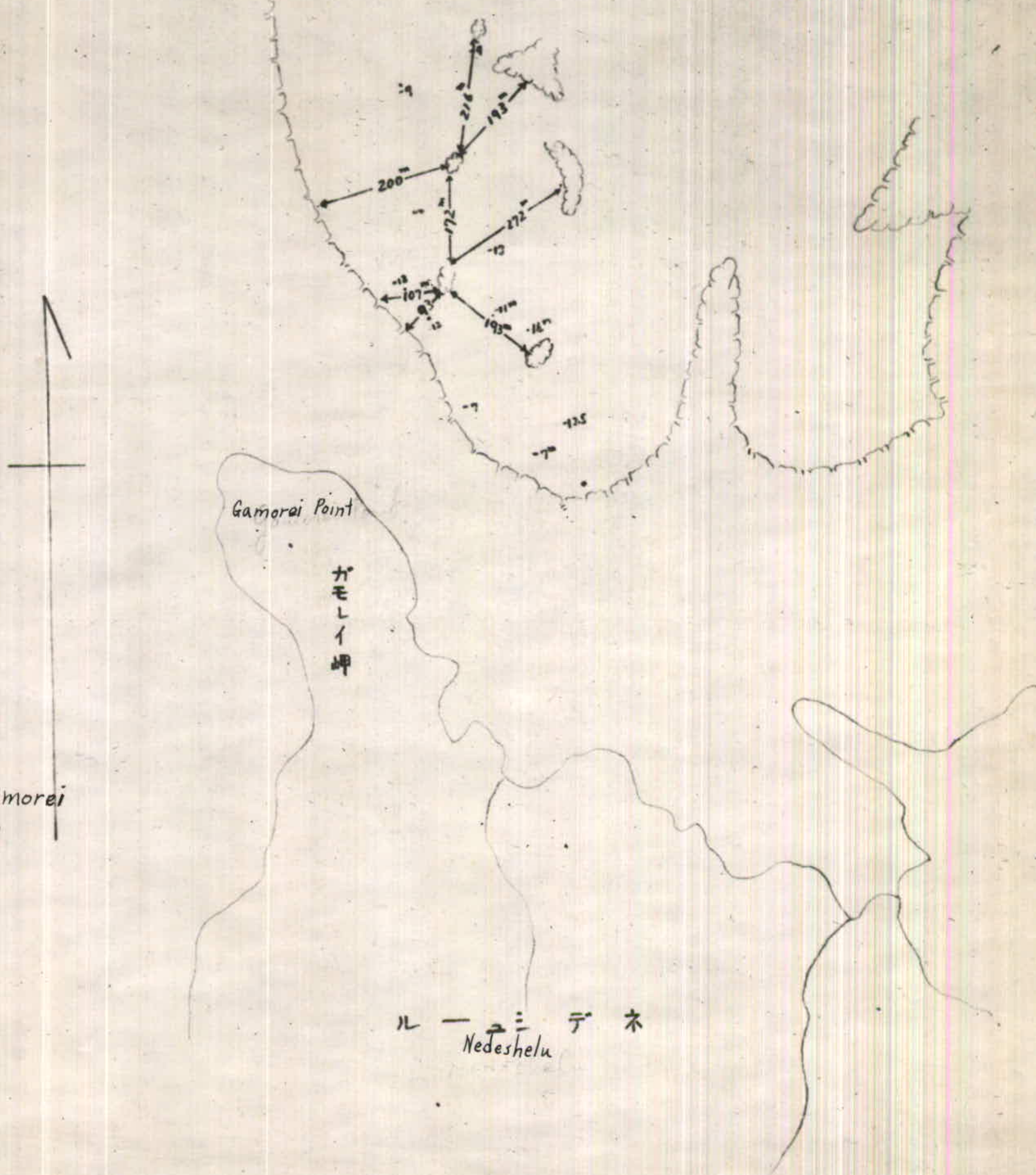
計 97.79 ÷ .1 = 8.89 s.f.

8.89 × 30 = 266.7
31^5 ÷ 0.8 = 39^5
266.7 ÷ 39 = 6.84 M.S.
410.9 M.M.
大旱魃時予想水量(1/12)
32 4 M. H.

ガモレイ錨地之圖

1/12,000

Map of Gamorei Anchorage



17.

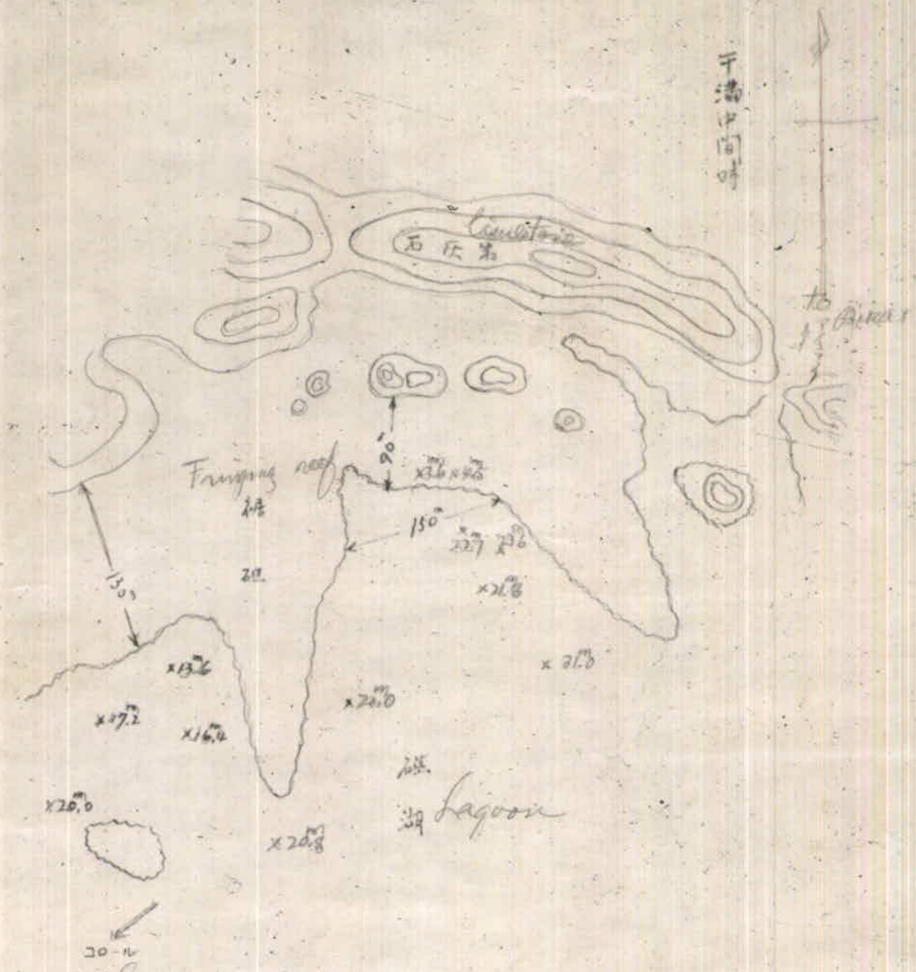
パラオ本島西海岸
水道之圖

21

19. Anchorage of AIRAI

Airai (detail) for jetty

アイライ錨地見取図



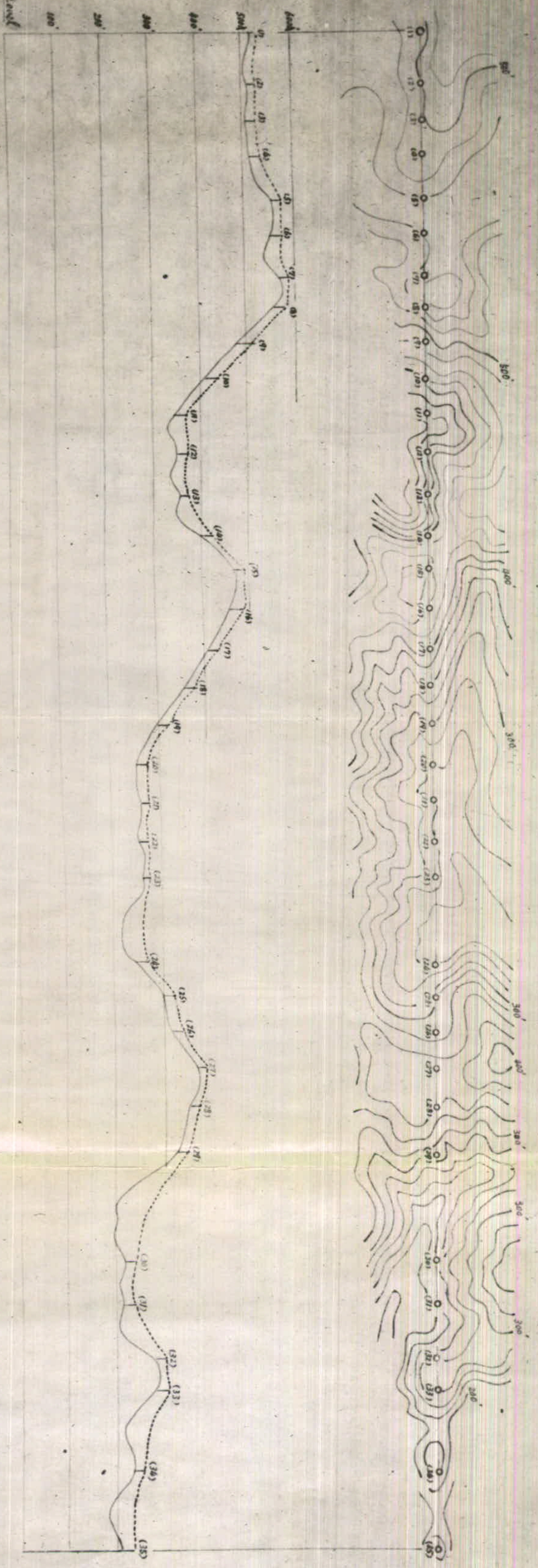
to Coral

オーゲルターゲル水道

Orgeltargel channel

OGURUTAAGERU PASSAGE

勾配 Slope	累計 Accumulated distance (in feet)	間隔 Distance (in feet)	Station
			(1)
	320	450	(2)
	750	300	(3)
	1,050	300	(4)
	1,450	400	(5)
	1,750	300	(6)
	2,100	350	(7)
	2,350	250	(8)
	2,650	300	(9)
	2,950	300	(10)
	3,250	300	(11)
	3,550	300	(12)
	3,900	350	(13)
	4,250	350	(14)
	4,550	300	(15)
	4,850	300	(16)
	5,200	350	(17)
	5,500	300	(18)
	5,800	300	(19)
	6,100	300	(20)
	6,400	300	(21)
	6,750	350	(22)
	7,050	300	(23)
	7,750	700	(24)
	8,050	300	(25)
	8,350	300	(26)
	8,650	300	(27)
	8,950	300	(28)
	9,350	400	(29)
	10,250	900	(30)
	10,650	400	(31)
	11,100	450	(32)
	11,350	250	(33)
	12,050	700	(34)
	12,700	650	(35)



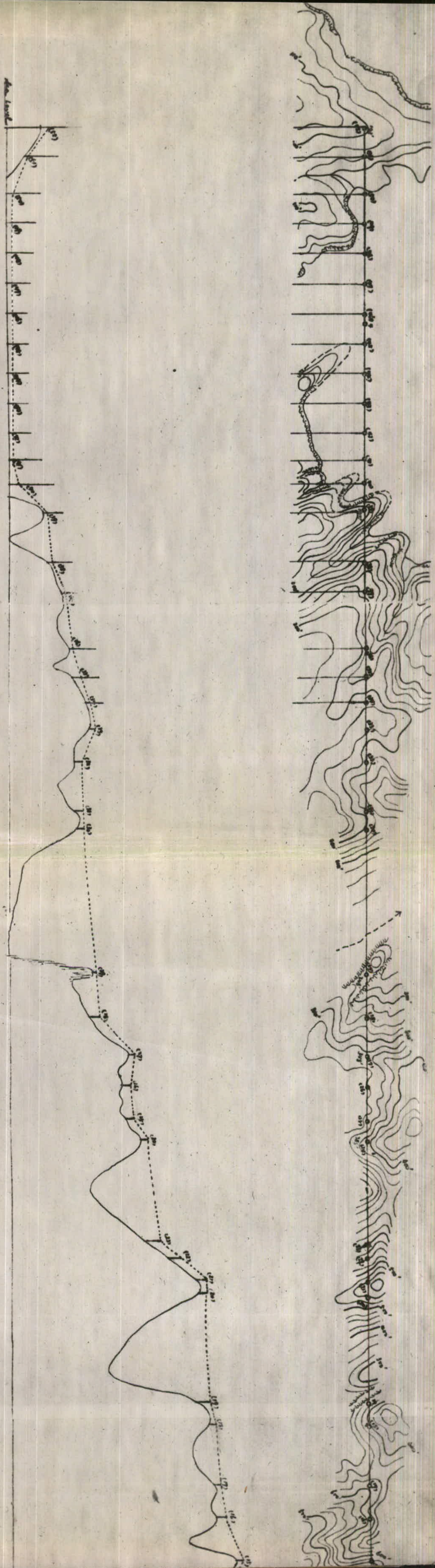
20

大平山
ガラスマオ
架空鉄索試案

Proposed Aerial Rope-way between Taihei Mt and Garasumau

縮尺 Scale
横 一万二千分一 Horizontal 1:12,000
縦 三千分一 Vertical 1:3000

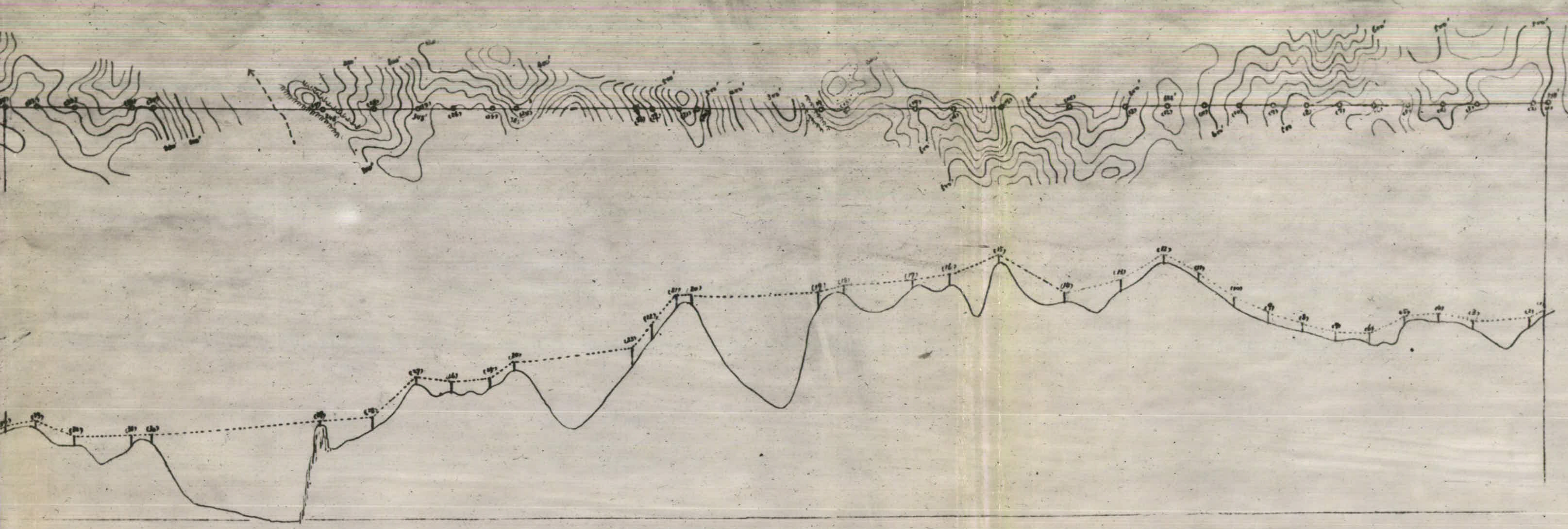
Accumulated Distance 累計 (in feet) 尺	Distance 間隔 (in feet) 尺
23,100	350
22,750	450
22,300	350
21,950	350
21,600	350
21,250	350
20,900	350
20,550	350
20,200	350
19,850	350
19,500	350
19,150	350
18,800	350
18,450	600
17,850	350
17,500	650
16,850	350
16,500	350
16,150	350
15,800	400
15,400	600
14,800	200
14,600	1,750
12,850	550
12,300	450
11,850	350
11,500	400
11,100	250
10,850	1,250
9,600	200
9,400	300
9,100	200
8,900	1,300
7,600	300
7,300	700
6,600	400
6,200	500



Proposed Aerial Rope-way between Taikei Mt. and Aimon

大平山アイミオン架空鉄道試案

縮尺 Scale
横 一万二千分ノ一 Hor. 1:12,000
縦 三千分ノ一 Vert. 1:3,000



16,150	15,800	15,400	14,800	14,600	12,850	12,300	11,850	11,500	11,100	10,850	9,600	9,400	9,100	8,900	7,600	7,300	6,600	6,200	5,700	5,000	4,400	3,950	3,550	3,200	2,850	2,500	2,150	1,800	1,450	1,100	750	150
350	400	600	200	1,750	550	450	350	400	250	1,250	200	300	200	1,300	300	700	400	500	700	600	450	400	350	350	350	350	350	350	350	350	600	150

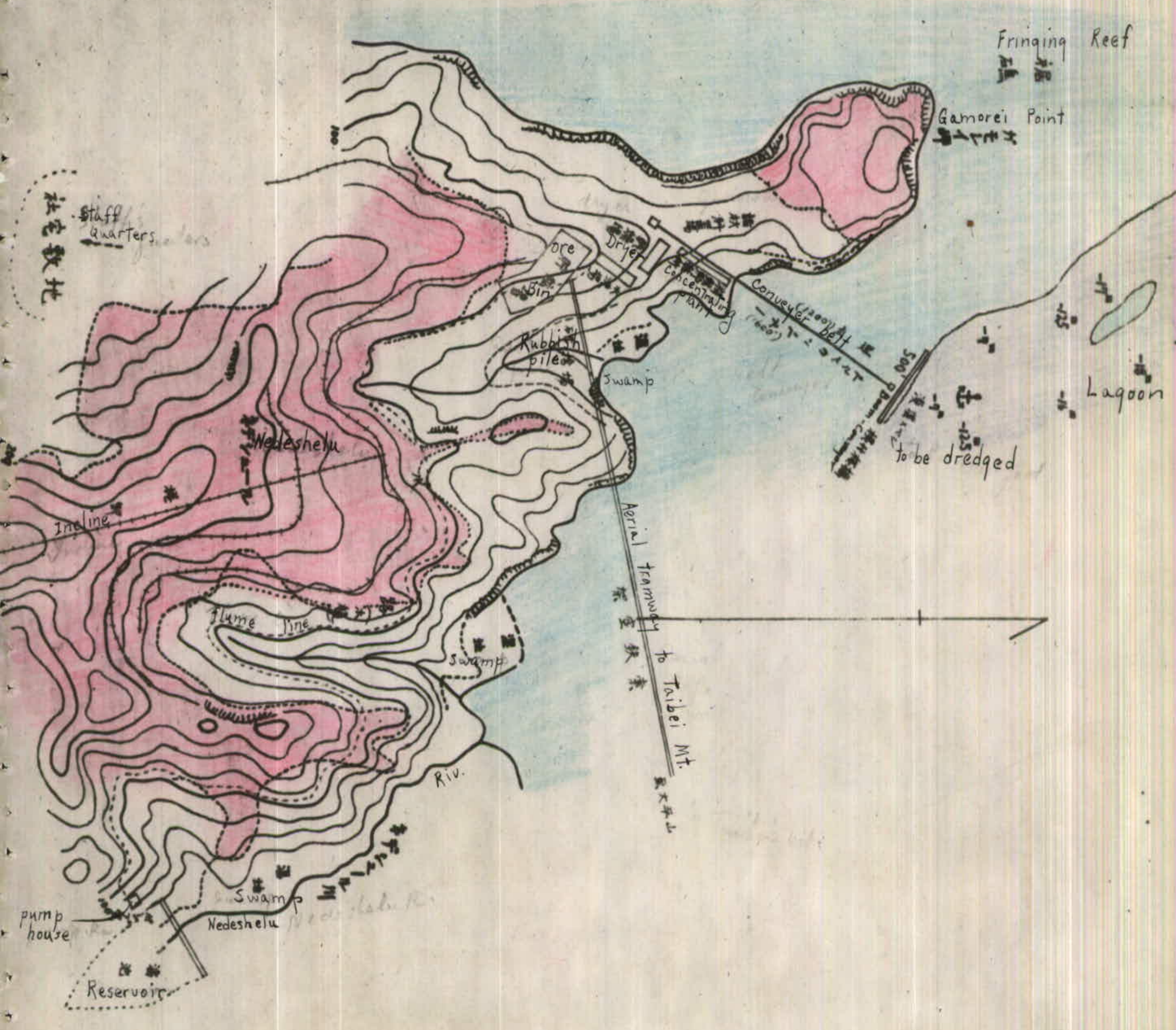
23

Proposed layout at Aimion Nedeshelu

contour interval, 25 feet
Datum, high tide

縮度一万二千分ノ一

アイミオンネデシェール地形圖



22

Proposed Layout at Ngardmau

Contour ~~line~~ interval, 25 ft. Datum is high tide

Proposed Layout at Ngardmau (GARASMAU)

パラオ本島 ガラスマオ附近地形圖

縮度 一万二千分之一

Scale 1:12,000

Staff quarters

Pump room

Atet Riv.

Generator

Swamp

Garasmau Valley

Swamp

Aerial Tramway

To Taibei Mt.

Tower

Ore shed

Washing plant

Drier

Conc. house

Rubbish pile

Endless

Conveyer belt

Mangrove

~~Manglope~~

Fringing reef

Reclamation Area

Lagoon

Endless

2200'

Loading pier (40 ft. upper width)

24 Cost Estimate of Bauxite Mining, South Sea

First plan. Establish the plant at Garasmau, (The figures are nearly the same when the plant is established at Aimiou)

Mines only the surface deposit.

Summary

Out put 100 tons per day, 30,000 tons per year. Selling price ~~on board at the factory~~ at Port in Japan is assumed Y 25.00 per ton.

Direct Cost

Mining place	Ton per tsubo	Mining cost include transportation (200m by tab.)	Land transportation cost: Distance	Land transportation cost: Truck cost (including road Repairing cost)	Ferry transportation cost (To NGARDMAU): Distance	Ferry transportation cost (To NGARDMAU): Transportation cost	Ferry transportation cost (To NGARDMAU): Loading & unloading cost	Washing cost	Ore ~~House~~ STORAGE cost (Natural) (drying)	Loading cost	FREIGHT ~~Steamer~~ charge to PORT ~~factory~~ in Japan moisture 10%	Total Cost ~~on board at factory~~ TO PORT	Ratio of ore quantity
	ton	Y	Ken	Y	Ken	Y	Y	Y	Y	Y	Y	Y	
Garasmau	0.55	1.39	3.2	1.51	-	-	-	0.75	0.10	1.00	6.60	11.35	56
Aimiou	0.38	2.00	1.2	0.75	14.5	0.70	0.00	0.75	0.10	1.00	6.60	12.90	12
Galmus-Kan	0.37	2.00	0.8	0.61	30.4	0.90	1.00	0.75	0.10	1.00	6.60	12.96	7
Algebraic average	0.43	1.55	1.73	1.31	22.5	0.20	0.25	0.75	0.10	1.00	6.60	11.75	

Note: Average cost for mining and land transportation are the algbraic average.

Indirect cost

Article	Amout	Cost per ton
	Y	Y/ton
Salary and alowance	71,320.00	2.377
Land rental	376.00	0.013
Managing cost	29,500.00	0.983
Field office ~~Mining~~ cost	11,250.00	0.375
Head office cost	14,340.00	0.478
Depreciation (45% for 10 years)	49,176.92	1.640
Tax(mine concession tax, mine production tax)	17,164.00	0.572
Total	193,126.92	6.438

	¥ per ton ~~¥ Yken~~
Direct cost	11,750
Indirect cost	6,438
Total	18,188
"	25.00
"	18,188
Profit.	6,812

Mining Cost of Bauxite, Palau. ~~Estimated~~ Estimate of Aimion Office (Annual production of concentrate 30,000 tons.
(Both surface and deep seated deposit ore mined.

Direct Cost (per ton)

Mining place	Distance Land	Distance Sea	Mining cost	Landtransportation Aerial rope way	Landtransportation Truck etc.	Sea transportation Charge	Sea transportation Loading & un-loading	Washing	Rubbish piling	Drying	Ore Storage	Loading	Charge of Freighter & insurance	Cost on Freighter to Port in Japan	Ratio of ore
	Km	Km	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	%
Ngatpang old	2	20	2.00		0.66	0.80	1.00	0.85	0.07	1.00	0.10	0.50	6.00	12.98	4
" new	1	15	3.00		0.66	1.40	2.00	1.53	0.23	1.00	0.10	0.50	6.00	16.42	1
Gakumiyskan	3	20	2.00		0.99	0.80	1.00	0.85	0.07	1.00	0.10	0.50	6.00	13.31	7
Aimion	1		2.50		0.50			1.15	0.19	1.00	0.10	0.50	6.00	11.94	23
Arumatsen	4		3.70		2.92			1.60	0.28	1.00	0.10	0.50	6.00	16.10	1
Arumasaka, S	4		2.50	1.00				1.19	0.15	1.00	0.10	0.50	6.00	12.44	6
" N	1	4	2.50		0.50	0.45	1.50	1.19	0.15	1.00	0.10	0.50	6.00	13.89	1
Elusum, Makelulu	7		2.50	1.56				1.10	0.12	1.00	0.10	0.50	6.00	12.88	46
Garasmau, W	3	14.5	2.20		1.50	0.75	1.05	0.87	0.08	1.00	0.10	0.50	6.00	14.05	1
" E	4	14.5	2.20		1.80	0.80	1.10	0.95	0.09	1.00	0.10	0.50	6.00	14.54	6
Gakulau, on the waterfall	6	14.5	2.20		2.40	0.70	1.00	0.85	0.07	1.00	0.10	0.50	6.00	14.82	4
Algebraic average			2.429		1.248	0.190	0.262	1.078	0.131	1.00	0.10	0.50	6.00	12.938	

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Indirect Cost (per ton)

Article	Amount ¥	Per ton ¥	
Salary & allowance	71,320.00	2,377	
Land rental	376.00	013	
Managing cost	29,500.00	983	
~~Mining~~ Field office cost	11,250.00	375	
Head office cost	14,340.00	478	
Depreciation	60,944.00	2,031	Interest 4.5% 15years.
Tax (mine concession & (mining products.	34,140.00	1,138	Mining concession 24,000,000 tsubo. Prospecting concession 80,000,000 tsubo.
Total	231,870.00	7,395	

Summary

	Y
Direct cost	12,938
Indirect cost	7,395
Total	20,333

Assur~~ing~~ed selling price on ~~board at factory~~ freighter at port in Japan is Y 25.00

Profit per ton Y 4,667

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Detail of Mining Cost

The ~~excavation quantity~~ amount of ore to be mined (earth included) per head is 0.5 cub. tsubo when the ore tonnage is 0.38 m tons per tsubo (~~depth~~ thickness 0.18m).

The Bauxite quantity contained in this excavated earth is 1.92 m ton.

(1 cub. tsubo is 8 tons including moisture. $8 \div 2 \times 0.8 \times 0.6 = 1.92$)

The members necessary for the mining of 1.92 tons per day is miner 1, loading tub and transportation 1 (~~if case happened screens~~ He may screen the ore, too)

Replacing rails and other works 1. Total 3.

Average labour cost is Y 1.20 Japanese and Islanders.

That is, mining cost per ton is Y 3.60 ÷ 1.92 = Y 1.87

cost of tools		0.13
	Total	Y 2.00

When the depth of deposit is increased the cost is decreased.

That is, the average cost of mining is Y 1,546 for the three districts of Garasmau, Aimion and GarumisuKan. The average tonnage per tsubo is 0.43 m ton.

		Tonnage	Cost per ton	Mining cost	Average
Details:-	Garasmau, Gakurau	558,014	1.39	775,639.00	
	Aimion	123,364	2.00	246,720.00	
	GarumusuKan	67,996	2.00	135,992.00	
		749,370		1,158,351.00	1.546 ≒ 1.55

Details of Land Transportation Cost

2 ton-truck is to be used. Excavated earth contains 40% of mud.

Mining place	Distance Km	Time for one round trip min	Time for loading & unloading min	Trips per day net 6hrs trip	Transported ore per day ton	Daily Cost: Oil ¢ 5.8 /km Y	Wages 2 heads Y	Repairing ¢4 /km Y	Depreciation Y	Total Y	Per ton Y	Road repairing per ton Y	Cost per ton Total Y	Ratio of ore
Garasmau	3.2	60	30	4	4.8	1.48	4.00	1.02	.46	6.96	1.45	.06	1.51	56
Aimion	1.2	20	30	7	8.4	.97	4.00	.67	.46	6.10	.73	.02	0.75	12
Garumisu-Kan	0.8	15	30	8	9.6	.74	4.00	.51	.46	[illegible].71	.60	.01	0.61	7
Average		32	30	6	5.6	1.063	4.00	.703	.46	[illegible].257		0.03	1.304	

Cost of transportation by lighters

Mining place	Distance km	Navigation trips	Fuel per ton Y	Wage per ton Y	Depreciation per ton Y	Repairing per ton Y	Total per ton Y	Per ton of Conc. ore Y	Ratio of ore
Aimion	14.5	1	0.109	0.125	0.139	0.047	0.420	0.700	12
Garumis-Kan	30.4	1	0.228	0.125	0.139	0.047	0.539	0.898	7
Average	22.5		0.169	0.125	0.139	0.047		0.773	

Remarks

Transport 60 tons ore by 2 ~~ferrys~~ lighters and 1 tug boat. Ore is transported from mining place to washing plant at Garasmau. Contains 40% mud.
2 ~~Ferrys~~ lighters capacity 50 ton per lighter are used.

Cost of ~~oil~~ Fuel:- 20 Hp. Consumption is 0.3 gal/km navigation. Price of ~~oil~~ Fuel Y 0.50 per gal.

For 14.5km =Y 6.25 (Loaded trip consumes double quantity of oil 14.5x0.3x2 = 8.7 gal
(Empty trip 14.5x0.3 = 4.35
13.05
Y0.50x13.05 = ¥ 6.25

Cost of ~~oil~~ Fuel per ton Y 6.25 ÷ 60 = Y 0.109
For 30.4 km = Y 0.228

Wages:- Crew of tug boat 2 @ Y2.00) Total Y7.50 Wage per ton Y 0.125
" of lighters 2 @ Y1.50)

Repairing cost: Tug boat Y1,200.- 2 ~~ferrys~~ lighters Y500.- Total Y1,700.- cost per ton Y 0.047

Depreciation:- Tug boat 1-20 Hp Y 3,500.-) Y 7,500.- 7,500 ÷ (60 tons x 900 days) = Y 0.139 per ton.
~~Ferry~~ Lighter 2-50 ton Y 4,000.-)

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Details of Washing Cost

Pump up the water (sea water is available) by 10^{Hp} pump

Shaking the ore in 1/8" screen and wash by shower. Daily treating ore amount in 2 tons per head.

		Y
Average wage Y 1.20	cost per ton Y 1.20 - 22	0.60
Pump cost		0.10
~~Consumption~~ depreceration cost		0.05
		0.75

Cost of Ore housing

The ore washed is transported to ~~be~~ the ore house after drain~~ing~~ off the water and left natural drying ~~at~~ there. ¥ 0.10 is required for transportation and water draining.

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Indirect Costs (office, etc)

Production per year 30,000 ton

Salary and allowance

Cost per ton 2,377

Staffs at mine

Staff	No.	Remarks	Inland Salary	South sea Salary+100%	South sea salary 1 year	Allowance	Total
General manager	1		Y 250	Y 500	Y 6,000	Y 1,000	Y 7,000
Office manager	1		150	300	3,600	600	4,200
Chief mining engineer	1		150	300	3,600	600	4,200
Office staff	5	(general, labour, (~~godown~~ storage, shipping, (accounting	Y 100 60x2 40x2 total 300	200 120x2 80x2 total 600	7,200	1,200	8,400
Mine engineer	5	(mining proper 3, (surveyor, transpor- (tation	100 60x2 40x2 total 300	200 120x2 80x2 total 600	7,200	1,200	8,400
~~Medical engineer~~ Machinist	1		70	140	1,680	280	1,960
Architect~~ure~~	1		100	200	2,400	400	2,800
Washing staffs	1		70	140	1,680	280	1,960
Doctor	1		200	400	4,800	800	5,600
Hospital staffs	1		100	200	2,400	400	2,800
				Total	40,560	6,760	47,320
				Per ton			1,577

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Staffs at Head Office   Total = Y 24,000   per ton Y 0.80

Note:- No. of labourers

	Japanese	Islanders	Total
Miner	100	100	200
Washing & ore house	35	35	70
Transportation (crews & truck)	24	26	50
Miscelaneous	20	5	25
Total	179	166	345

25 Installation costs

Article	Details	Unit	Amount
		Yen	
Mining equipment	20lb rail 2 miles 50 tubs, etc.		13,800
Pier	1 pier, Jetty for boat & ~~barry~~ lighter		20,000
Washing plant	Building , 250 tsubo (including wage)	60	15,000
	Concrete 25 cub.tsubo	150	3,750
	Screens, pipes		500
	Pump ~~2 20~~ Two 7-10 Hp ~~with~~ engines	3,000	6,000
	Transportation and installation of pump		1,400
	Earthwork		4,000
			30,650
Ore house	Bulding 375 tsubo, (including wage)	70	26,250
	Concrete 37.5 cub.tsubo	150	5,625
	Earthwork		5,000
	Tub 10	100	1,000
			37,875
Buildings	Office $12^{ken} \times 8^{ken} = 96$ tsubo	120	11,520
	Furnitures		500
	~~Godown~~ Storage $10^k \times 6^k$ = 60 tsubo	90	5,400
	Dormitory and club house 90 tsubo	120	10,800
	Furnitures		1,000
	Hospital 90 tsubo	120	10,800
	Furnitures & equipments		4,000
	Mine office 50 tsubo	90	4,500
	Furnitures & equipment		3,000
	~~Mechanical factory~~ Machine shop 50 tsubo	100	5,000
	Equipment		3,000
	~~Architectural factory~~ Carpenter shop 90 tsubo		4,500
	Equipment		2,000
	Staffs quarters A 1-40 tsubo (barrack)	130	5,200
	B 3-30 "	110	9,900
	C 12-20 "	100	24,000

Article	Details	Unit	Amount
Building	Labourer's quarter 120 houses -12 tsubo for Japs.	80	115,200
	100 -7 tsubo for Islanders.	60	42,000
	Labourer's dormitory 100 tsubo	80	8,000
	Water tank 31 places	150	4,650
			274,970
Road	2 ken x 8,000 ken	5	40,000
Total			417,295

Supervising Cost for Installation

		Amount	
Period one year	Travelling allowance & salary		
	1 - engineer	10,000 Y	
	2 - Assist, engineer	12,000	
	3 - Temporary staff	10,000	
	Total	32,000	
Prospecting cost	Total	110,000	
	For Palau I.	55,000	
	For ~~Galemas~~ Garasmou		40,000.00
Reserved cost for installation	10% of Installation cost		45,000.00
Grand Total			534,295.00

~~Depreciation~~ Cost is to be ~~finished~~ paid in 10 years, with output of 30,000 tons /year. Interest 4,5% annually.

Depreciation amount/year 0.081379x534,295=43,480.- Y

Depreciation per ton 43,480.- ÷ 30,000 = 1,449Y

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1 chobu=3,000 Tsubo = 1 hectar
1tsubo =36sq.ft or 1 sq.ken

Land rental

Land Condition	Area chobu	Rental per 1 chobu Y	Annual rental Y
Building area	20	2.00	40.00
Washing plant, pier etc.	5	2.00	10.00
Road	13	2.00	26.00
Prospecting	first 5 years 150	2.00	30.00
		[illegible]	376.00
		per ton	0.013

Office cost

Article	head	Amount Y	Per ton Y
Wages	10 1.50	4,500	0.150
General cost & welfare for mines		6,000	0.200
Stationaries		1,000	0.033
Communication		2,000	0.067
Reception		4,000	0.133
Repairing		3,000	0.100
Hospital		1,000	0.033
Traveling allowance		8,000	0.267
	Total	29,500	0.983

Head office cost

Article		Amount Y	Per ton Y
Stationaries		300	0.010
Reception		3,000	0.100
Selling cost	12% of the cost on ~~board~~ Freighter off Garasmau Coast.	11,040	0.368
Total		14,340	0.478

Mining office cost

Article		Amount	Per ton
Wages	head 15 @ 1.50	6,750	0.225
Stores		3,000	0.100
Chemical & tools for assay		1,500	0.050
		11,250	0.375

		tsubo	Y		Y
Mining Tax	Area of concession	15,000,000	15,000	Per ton	0.500

Taihei mt. - Aimion 100Hp
Taihei mt. - Garasmau 75Hp
NET 7hrs 330 tons

Costs for aerial tram

Tons per hr.	Cables dia.	Carriers capacity.	price per ft.	K.M.per cost.
			Y	Y
50 ton	13/8-19/8	0.5 ton	5.00	16,500

Distance Taihe mt.-Aimion 6.4 x 1.05 = 6.57 k
Taihei mt.-Garasmau 4. x 1.05 = 4.2

Installation cost	Aimion plan	Garasmau plan
	Y	Y
Line machinery	110,000	69,000
Terminal station w. machine	10,000	10,000
Intermediate stations 2	6,600	3,300
Motor	4,800	3,200
	131,400	85,500
Coefficient for South sea ~~function~~	1.3	1.3
Real cost	170,820	111,150
Depreciation per ton	Y 0.233	Y 0.154

Line machinery including tower equipment, cables, ropes, and carriers,

Tower taken as 250ft.

Line speed 500ft per minute.

Machinery for two terminals, including all metal work and belt, but no motor or Automatic generator. price 10,000 Y weight 3000 lb

Motors with solenoid brake, controller, transformer, oil switch. 500r.p.m.

1,000-1,200 volts.

50 Hp 1 Hp per 64¥ 100Hp 1 Hp per 48¥

Detail of the wage of aerial rope way(one day)

		@	Amount		Repairing 5% of the first cost.
	1 brake man	Y 2.00	Y 2.00		
	4 terminal man	1.50	6.00		
	1 oil man	3.00	3.00		
	2 miscelaneous	1.20	2.40		
Total	8		13.40	per ton 0.134	per ton 0.283

Transportation cost can be reduced when the ore is sent to Garasmau and washing plant is installed there, but as the distance to pier is long and loading cost is increased, the total cost is estimated to be nearly the same ~~at two cases~~ either to be transported to Garasmau ~~and~~ or to Aimion.

26. Summary of installation costs — When the plant is installed at Aimion.

Articles	Details	Amount	Remarks
Mining equipment	Rail — 4 miles @ ¥5,000	20,000.00	
	Hoist — 50Hp motor, including transportation charges etc.	9,000.00	
	Tub — 1 ton-iron 100tubs @ 300	30,000.00	
	Construction of railtrack, including earthwork	15,000.00	
	Miscellaneous metals	3,000.00	
		77,000.00	
Pier & Loading equipment	Reef masonry & reclamation $2^{k} \times 2^{k} \times 100$ Ken @ ¥60	6,000.00	
	Cutting(from ore bin to jetty)	2,000.00	
	Pier (Iron) 100Ken @ ¥750	75,000.00	starting ~~end~~ height 12 shaku high
	Belt conveyor 1700" @ 40, 75Hpmotor, etc.	68,000.00	at the end 42 shaku high
	Suspension bunker	15,000.00	
	Jetting equipment of steamer, including dredging	40,000.00	
	Signs for water course (Garasmau channel-Aimion)	10,000.00	
		216,000.00	
Washing plant, equipment	Building(wooden)including foundation	30,000.00	
	Machines including installation cost	150,000.00	
	Water supplying cost	44,000.00	100Hp pump 2 ¥14,000; Tank ¥10,000; water line ¥10,000; Dam ¥10,000
	Rubbish pile equipment	20,000.00	
	Earth works(miscellaneous)	5,000.00	
		249,000.00	
Dryer equipment	Dryer Building(wooden) including foundation	20,000.00	
	Rotary driver 1,furnace, conveyor etc.	60,000.00	
		80,000.00	
	Total	622,000.00	
Miscellaneous building		194,000.00	
Electric power station	400k.w. @ ¥300	120,000.00	
Ships	Motor-tug boat 50Hp 1 ¥8,000; 15Hp 1 3,000; 3 lighters 3,000 @	20,000.00	
Land rental		10,000.00	Purchasing cost of village land & private land)
Supervising cost for installation		40,000.00	
Prospecting cost		130,000.00	
Reserve for installation cost		113,000.00	
		1,249,000.00	

Amortization ~~Depreciation~~ in 15 years; interest 4.5%/year

Annual amortization ~~depreciation~~ ¥ 60,944.00

Annual production 30,000 ton — Amortization ~~Depreciation~~ per ton ¥ 2.031

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Costs of ~~depreciation of~~ amortization per ton for installations according to washing recoveries.

Article / Recovery	Base amount 60% ¥	Increasing amount 30% factor 1.8 ¥	25% 2.16 ¥	20% 2.7 ¥	10% 5.4 ¥
Washing installation cost	400	320	464	680	1,760
Mining installation cost	126	100	146	214	554
Building cost	311	249	361	529	1,368
Power station cost	193	factor 1.2 154	1.44 224	1.8 328	3.6 849
Supervising cost of installation	064	013	028	051	166
Reserved cost for installation	181	036	080	145	471
Total	1,275	872	1,303	1,947	5,168

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27. ~~Operation~~ Mining ~~Office etc.~~ Operation costs according to washing recoveries

August, 1936

(By Aimion office. Annual production 30,000 tons)

Article \ Recovery	60%	30%	25%	20%	10%
Mining cost	Surface deposit ¥ only 2,000	Depth of deposit Y 3,000 -1.20m	3,750	4,500	9,000
Transportation cost	330	660	800	1,000	2,000
Washing cost	850	1,530	1,836	2,295	4,590
Rubbish piling cost	070	230	300	400	900
Drying cost	1,000	1,000	1,000	1,000	1,000
Ore housing cost	100	100	100	100	100
Roading cost	500	500	500	500	500
Steamer charge (including insurace)	6,000	6,000	6,000	6,000	6,000
Indirect cost	7,757	8,161	8,797	9,656	13,757
Total	18,607	21,181	23,077	25,451	37,847
Loss & profit against Y25,- to be received on ~~board~~ Freighter at ~~factory~~ Port y in Japan.	6,393	3,817	1,923	-451	-12,947

Remarks: From above results, safety workable recovery is + 25%.

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28. Indirect costs (same as preceeding page).

Article / Recovery	60%	30%	25%	20%	10%
		4 heads increased	5 heads increased	6 heads increased	12 heads increased
Salary & allowance	2,377	¥ 2,577	¥ 2,627	¥ 2,677	¥ 2,977
Land rental	013	010	010	010	010
Managing cost	983	1,203	1,313	1,423	1,863
Plant cost	375	490	535	590	730
Head office cost	478	478	478	478	478
~~Depreciation~~ Amortization of installation cost	2,031	2,903	3,334	3,978	7,199
Tax	500	500	500	500	500
Total	7,757	8,161	8,797	9,656	13,757

These are ... [illegible]

29. Comparison of costs by Districts

Relative increase~~ment~~ of mining cost of Makeruru mt. & Taihei mt. against Aimion.

Daily crude ore 330 ton or conc. 100 tons

Recovery 30%

Transport to Aimion washing plant by Aerial rope way.

Rope-way cost	~~per ton~~ #	Wage	Power	Repairing	Depreciation	Rope cost	Total
	100Hp	0.134	0.210	0.283	0.233	0.735	1.595 ¥

Electric line, ~~Depreciation~~ Amortization & repairing cost @1 k.m. Installation cost 3,9000 Yen k 6.7 total installation 26,130 Yen ~~Depreciation~~ Amortization per year 1,257 ¥

~~per ton~~ # 0.042 Repairing cost ton 0.010 Total ¥0.052

Increase~~ment~~ of houses & mining equipment
(10% ~~is~~ increase~~d~~ for installation cost as the place is inconvenient about 22,700 ~~Depreciation~~ Amortization ~~per ton~~ # ¥ 0.036

All costs are increase/ 10% as the place is inconvenient the, the increase of mining cost per ton is, 0.300

Increased no of staffs Eash one staff is increased for mining & labour section
Annual salary @ 1,500.- per ton 0.100

For the conclusion~~m~~ The increased cost is as follows.

Rope way	1,595
Electric line	052
~~Depreciation~~ Amortization	036
Mining cost	300
Staff's salary	100
Total	2,083

Total cost 21,181 + 2,083 =Y23,260
Profit 25,000 - 23,264=¥ 1,736

That is, working is not safe if the recovery is less than 30%
economical.

Labor wages (By Palau Local Government)

	hrs	@ ¥
Ship and house carpenter	Labour hours 10 /day including ~~intermittest~~ rest period of 1½ hrs to 2 hrs.	1.50 - 5.00
Blacksmith	"	3.50
Plasterer and stone mason	"	3.50
Sawyer	"	3.50
Common labourer	"	1.00 - 2.00
Miscellaneous miner	"	3.00
Miner, proper	"	5.00

(Note: Wages for miners miscellaneous and proper are paid for their special ability.)

For islander miner, free board and house are supplied	0.45 - 0.50
Common islander labourers	0.70

no. 307

2nd TEST DRILLING AT KITA DAITO-ZIMA

BY

Toshi~~y~~o Sugiyama

Institute of Geology and Paleontology,

Tohoku Univ., Contrib. in Jap. Lang.

No. 25, 34 pp., 1936

CONTENTS

SECOND TEST DRILLING IN KITA DAITO-ZIMA

By Sugiyama Toshiro

1. PREFACE

As a result of laboratory research on samples collected in the first test drilling of Kita Daito-Zima, various interesting problems cropped up. The Tone Boring Rig Manufacturing Co. (Tone Seisaku Eigyosho) was entrusted with the task of carrying on the second test which was started at the depth of 209.26 meters, the point reached by the first test well. The 2nd test drilling lasted from the middle of January, 1936 to the latter part of April, 1936. The combined borings reached 431.67 meters (1416.22 feet). This depth is less than that of the test well at Key West, Florida; however, it is deeper by 95.10 meters than the wells in Ellis and Funafuti Islands. This kind of drilling was never before carried out in Japan; therefore, it is needless to say that much valuable study material was collected. In the Key West drilling, a cable tool drill rig was used, so the samples were recovered in powdered form; whereas, in Funafuti and Kita Daito-Zima, a rotary drilling rig was used in order to recover the samples in cylindrical form. These cores may be the deepest ever recovered as material for pure scientific research. I was honored to be able to secure

permission from Prof. Yabe to participate in the test drilling in Kita Daito-Zima. I left Sendai on November 6, 1935. Boarding the Kano Maru,* 1200 ton, with Rokuro Endo, B. Sc., I left Moji on November 17th. Owing to inclement weather, the voyage took four days; we made harbor on the west coast of the island. Although the drilling was scheduled to start immediately after reaching the island, due to various problems which rose from time to time and delayed the undertaking, it actually started in early January.

I'd like to take this opportunity to express my sincerest appreciation to Prof. Hisakatsu Yabe who permitted me to be present on the Kita Daito-Zima, and to Prof. Renjiro Aoki who kindly revised this manuscript for me.

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II. RECORD OF DRILLING

A. Preparation

The arrival of Akio Iimori and Mitsuru Fujiki, both engineers, was unexpectedly delayed. The time awaiting their arrival was spent in recording the changes of water level of the ocean within the bore hole and of Akaike (pond near the shrine) with a tide guage, and in collecting hundreds of sample of limestone throughout the island in order to determine the character of the Daito limestone. Among these, the important ones, 50 or so, were analysed by Mr. Noboru Ishikura. Data on the analyses will be reported at a later occasion.

Mr. Iimori and Fujiki arrived at the island with the drill rig and its accessories in the latter part of December. Owing to poor weather, the installation of the rig and other necessary equipment was finally completed on January 12th. A large type Tone model universal drilling rig and a 6.5 HP Honda model engine were used. It was expected that the drill hole might be partly caved in and filled as in the case of the Funafuti drill hole. However, no difficulty was encountered, and we inserted the casing pipes down to 202 M. depth in 2 days.

The daily activity may be summed up by reading the following diary:

January 13

Began inserting casing pipes at 1321 hrs. Slight resistence was felt at 112.18 M. in depth. By using a wrench to twist the casing pipes in circular motion, we were able to insert the casing pipes down to 165 M.

January 14

Worked on inserting casing pipes, starting at 1200 hrs. (see Plate 2, Fig. 4). It took only 1 hr. and 30 minutes from 165 M. to 202 M. in depth. Slight resistance was felt at 199 M., but the casing pipes went through it by their own weight.

January 15

Cleaned the drilling rods. Sticky slime filled the rod and the sediment tube. The drilling did not progress as expected.

January 16.

Reached the 209.206 M. depth at 1231 hrs. at which depth the first test drilling had ended.

From the above diary one can conclude that the old hole had refilled very little. It is said, however, that the Funafuti drill hole was largely filled with slime and collapsed material from the walls, and that it took over a month to re-drill the hole.

Casing pipes used:

Inside diameter of casing pipe	67 mm
Outside " " " "	72 mm
Thickness of wall of " "	2.5 mm
Length	3 meters

B. Progress of Drilling

The joined casing pipes, not sufficient for the entire length of the drill hole, were supported by a casing band at the top [redacted]. The cores lifted were mostly in powdered form and very few in cylinderical form.

On January 18, the drilling started at 1000 hrs, and after 37 minutes of operation, 3 meters of depth was added to the hole, totaling 214.28 M. As the drilling progressed, the resistence gradually increased, forcing us to lift out the rod and check it. During this operation, the whole length of casing pipes, which were suspended by the casing band, dropped to 209 M., the depth at which the first drilling had stopped. The attempt to lift the casing pipes ended in failure.

As a result of the conference attended by Rokuro Endo, Akio Iimori, and others, it was decided to continue drilling without lifting the casing pipes to the original position. 6 meters of iron pipe (same diameter) was borrowed from the branch office to be added at the top end. When the casing pipes dropped, the lower end was damaged [redacted]. The 21st and 22nd of January were spent repairing it.

The drilling progressed smoothly until March 9th. At 217 M. in depth, strong resistance was felt. Between 217 and 223 M. in depth, cement was poured down several times in order to prevent the wall from collapsing. It is difficult to determine whether or not the collapse of the wall was due to the presence of a fault, but water gushed out of the hole when drilling was stopped. On the 20th of March before resuming the drilling: (1) A substantial amount of water had continued to gush out until 0850 hrs., and (2) gradually the amount of water decreased and finally stopped at 1120 hrs. Then the water level gradually lowered, but it did not return to the normal level. As the normal level of water is about 1.5 meters from the top of drill hole, the rise of water as mentioned above is noteable. This phenomenon was observed between 217 and 223 meters in depth, and it may be geologically significant.

During the first drilling, a depth of 200 M. was attained in a very short time, because the lithology was, in general, extremely soft below 103 meters. The second drilling was expected to progress fairly rapidly , but, on the contrary, though the lithologic character was similar, we encountered numerous difficulties. The main ones are as follows:

1. Lithology was soft, but in part, hard layers were encountered.

2. Therefore, the cores became powdered. Careful removal of powdered core takes many hours.

3. The walls of the hole collapsed easily, necessitating frequent cementation.

4. Sea water freely permeated the limestone; therefore, it was difficult to determine whether or not the cement hardened sufficiently.

5. Because of the softness of the rock, there was the fear that the hole might become crooked if the cement over-hardened. When the cement is suitably hardened, the walls of the hole appear to be not sufficiently hardened.

Towards the evening of March 9th, 42 meters of drill rod, the sediment tube, the mud tube, and the crown fell to the bottom of the hole. On the 10th we were able to lift up the entire apparatus. As a result, the wall was damaged badly, thus the cement was poured into the damaged part of the wall to strengthen it. However, two errors were committed during the process.

1. Length of wall hardened by cement was too long for one pouring.

2. Allowance of time for cement to harden was overestimated. Consequently the drill hole gradually curved from 285 M. in depth downwards. It took 12 days to straighten out the hole. After the above accident, great care was exercised in the pouring and hardening of cement.

After March 21st, the drilling progressed smoothly, and on April 17th, attained a depth of 398 M. Sometimes we drilled more than 8 M. a day. As the drilling continued, the wall at the upper part, reinforced with cement, gradually began to collapse. At this depth also the character of the rock changed and was no longer uniform. To meet the situation and to prevent further accidents, T.N.A. metal was attached to the cup ring, and a depth of 431.67 M. was attained at 1800 hrs. on April 24th (see Fig. 4). (Drilling ended here).

Daily progress is shown on ~~Chart~~ Table 1, and monthly progress on ~~Chart~~ Table 2.

C. Hours Required and the Depth Drilled

As shown in ~~Charts~~ Tables 1 and 2, 55 days were actually spent in drilling. The time spent on the operation was 5,191 minutes, in other words, 3 days, 14 hours, 31 minutes. In short, 222.41 meters in depth, (from 209.26 to 431.6 M.) were drilled in about 3 days.

3 days, 21 hrs., 43 min. were spent in the first drilling which attained a depth of 209.26 M. The first drilling required more time, and the depth attained was less than that in the second. If it is assumed that the pressure against the limestone, the revolution of the drill rod, the metal attached to crown, and other conditions were the same in both the first and second borings, it is readily conceivable that the lithologic character of the lower part of the hole is very soft.

It is needless to say that the hardness of rock governs rate of drilling. Other governing factors are the number of revolutions of the crown, the number of metal pieces attached and method of their application, the amount of water used, and weight on the crown. In the second boring, the water swivel (Plate 2, Fig. 5) was utilized to suspend the drill rod and other equipment by a rope in order that too much weight should not fall on the crown. As the depth increased, a balance was also attached to further lessen the weight on the crown (Plate 2, Fig. 6).

D. Draining of Water and Lifting of Slime and Core.

Casing pipes were used down to 209 M., which was the depth attained by the first drilling. During the first drilling, water did not gush out at any place when drilling through the soft limestone of the lower part. Because of this, we were worried when it happened during the second drilling, but the problem was soon resolved. Generally, the water returns to the top of the hole approximately 30 minutes after it is pumped down. Soon after drilling gets underway, the amount of water pumped out gradually decreases because it is blocked by slime. This is why continuous drilling for long hours had not been carried out. When the amount of water being pumped out decreased to a certain mark, the drilling was stopped. The water was pumped down at an average of more than 100 lbs. per minute, and became still greater as the depth increased. The amount of water returning to the top of the hole was greater during full tide than during low tide.

Very few cores were recovered in cylindrical or in lump form. Whenever cylindrical cores were not recovered, slimes inside the sediment tube were collected as a substitute. The size of the slime was fine-grained in general, immediately after the beginning of the drilling, and that recovered at the end of the one operation was approximately 1 mm. in diameter. Some of the material remaining in the sediment tube was larger than 2 to 5 mm. in diameter. The slimes recovered from below 240 meters were of foraminifera almost perfectly preserved because the limestone is composed of foraminiferal sand. (Plate 5, Fig. 3). Generally the size was 2 to 3 mm. in diameter, but a few reached 12 mm. in diameter.

The color of the water pumped out varied greatly, but it was generally cream white. On very few occasions the color turned greyish white or pale, greyish purple. This phenomenon was comparatively conspicuous at 231 M. in depth. The same color change was repeated lower, but it was not as noticeable as at 231 M. The change in color is, perhaps, caused by a difference in lithologic character, but its cause was not studied further because the cores recovered were all in powdered form.

Painstaking care was exercised in recovering the cores. First fine sand was pumped down the hole with the water in an attempt to recover the cores, but this failed. Cup ring and core shell were also used, but the result was almost the same. According to Mr. Endo and Mr. Iimori the reason why the cores are not recovered in cylindrical or in lump form is that they are powdered during the drilling.

E. Cementation

Cement was poured down the hole to prevent the wall from collapsing. Chichibu cement which comes in a paper bag was poured in at 1700 hrs. Drilling was resumed the next morning, but the results were unsatisfactory. On the next attempt, we started drilling the second morning after the cement was poured. This time the cement was felt to be a little over-hardened, but it didn't hinder drilling, so that this method was continued. Unfortunately, on March 10th an accident occurdd due to over-hardening of cement. When we investigated the nature of the cement, we found that the Asano cement, which comes in barrels, hardens quicker than Chichibu cement which comes in paper bags. We decided to use Asano cement thereafter. If the cement is poured in the morning hours, it was decided that drilling should start the following afternoon. In other words, drilling was resumed within 30 hours after the cement was poured. This proved successful in attaining the corect degree of hardening and in preventing the wall from collapsing. It is needless to say that a little calcium chloride is mixed with the cement to expedite hardening (~~See Chart 3~~). In order to strengthen a weak place in the wall cement was usually poured only once. But ~~as the chart indicates~~, repeated pouring of cement was necessary in certain parts of the hole.

The total weight of cement used for the second boring was 3000 kg. For the drilling alone 2400 kg. of cement was used, and the remainder was used for installing the equipment.

III CHARACTER OF THE CORE

The core recovered was mostly in powdered form, and very few solid cores were recovered from the core tube. Only 2.021 M. of core was recovered in cylindrical or in lump form.

The outer diameter of the crown used in the first boring was 85 mm. The percentage of recovery for the first 100 M. in depth was more than 70 percent. Below 100 M. the character of rock was uniform but not hard. Therefore, the average recovery was a little over 10 percent.

The outer and inner diameter of the crown used in the second boring was 65 mm. and 50 mm. respectively. The percentage of recovery was far less than the first drilling. For this reason, the lithologic character of the entire depth, 222.41 M., based on the study of cores is not as accurate as that of the first survey.

Judging from the cores recovered, the entire depth of the second drilling is stratified (Plate 5, Fig. 2). The appearance is sandy, and the size of grains is comparatively uniform. Most of them were 1 - 2 mm in diameter, but those recovered from 316.22 to 325.42 M. in depth were generally coarse, about the size of rice, and few were as large as a bean. Depressions as large as a walnut are found on the surface of the core, but it can not be assumed that there are large hollows developed within the limestone, as in the case of the first boring.

The color of the cores were generally white or whiteish which is similar to that of those recovered from the lower part of the first drilling. A slight difference is that when the cores of the second drilling were rubbed, one's hands were not whitened.

Fossils in the cores can not be determined accurately without using a microscope, but the most abundant were foraminifera, and second were the reef-building corals and algae. Mollusca were comparatively rare. Echinoid spines were also found occasionally. Cerithium (?) was abundant from 223.52 to 229.52 M.; foraminifera (Linderia?), from 247.62 to 291.37 M.; and reef-building corals near 215 M.; 291.37 to 294.02 M, and 317.36 to 319.22 M. in depth.

The cores recovered in cylindrical form or in lumps were numbered in sequence in the order recovered. The core recovered in powdered form was given a different series of numbers. For the cylindrical or lump cores, the smaller the number, the shallower the depth. (Table 4)

IV TEMPERATURE WITHIN THE DRILL HOLE

A thermocouple was used to determine the changes of water temperature within the drill hole (Table 5). Copper and constantan lines were protected by wrapping them with rubber so they could be used repeatedly. However, the method did not prove successful because the rubber was easily damaged. These determinations were started at 1400 hrs. April 18th, and were completed at 1700 hrs. of the same day.

Atmospheric temperature at 1400 hrs and 1700 hrs was 26°C and 24°C respectively. The temperature of the surface water of Akaike (pond) was 26.4°C at the time of the first reading of the temperature within the drill hole, somewhat higher than the atmospheric temperature. The temperature was taken at 10 M. intervals.

The temperature of the water dropped with an increase in depth (Fig. 6). The changing curve appears approximately like a parabola. However, It is thought that the change of temperature is primarily governed by the free permeation of sea water into the limestones which underlies Kita-Daito Zima. A fact worthy of note is that the temperature, in most cases, didn't drop 1°C in a 10 meter interval, but between 90 and 100 M. in depth the change was prominent. The same results were obtained in the first drilling. This may be caused by the remarkable difference in character of rock above and below 103 M.

the degree of lowering of temperature over a certain distance is known never to be regular when observed in detail.

V CHANGES IN WATER LEVEL

In addition to recording the rise and fall of water level within the drill hole, that of the sea level and Akaike pond was also recorded by using a tide guage. Date and hours of recording at various places is as follows:

At Minatoguchi Coast:

(1)	1425 hrs	Dec. 5	1308 hrs	Dec. 6
(2)	1620 hrs	Dec.20	1750 hrs	Dec.21
(3)	1145 hrs	Apr.30	1126 hrs	May 3

Well of Minatoguchi:

(4)	1358 hrs.	Dec. 7	0830 hrs	Dec. 10
(5)	0910 hrs	Dec 10	0909 hrs	Dce. 12
(6)	1030 hrs	Dec 14	0830 hrs	Dec 20
(7)	0835 hrs	Dec 20	0830 hrs	Dec 22

Within the drill hole:

(8)	0640 hrs	Dec 7	1100 hrs	Dec 4
(9)	0922 hrs	Dec 9	0930 hrs	Dec 15
(10)	1030 hrs	Dec 16	0630 hrs	Dec 19
(11)	1222 hrs	Dec 23	1030 hrs	Dec 29

At Akaike Pond:

(12)	1230 hrs	Dec 22	1030 hrs	Dec 29

A. Minatoguchi Coast

The coast of Kita Daito-Zima is largely surrounded by cliffs, and waves break roughly on the shore. Recording the rise and fall of sea level was thus difficult to determine.

As Plate 1, Fig. 1 indicates, a tide guage was first installed at the north side of the anchorage of Minatoguchi, at a site 1 meter above the full tide mark. A firm foundation was laid using lumber and cement. Recording of sea level began at 1425 hrs., Dec. 5, but at 1108 hrs., Dec. 6, the tide guage was swept into the sea.

The records registered by the tide guage are shown in Fig. 7 and Table 6. The difference between full and ebb tides was greater in the afternoon than in the forenoon, 1.205 M for the former and 1.048 M and 0.760 M. for the latter.

The second recording of sea level at Minatoguchi continued for 25.30 hrs, starting Dec. 20th. The results were not satisfactory. Figure 8 and Table 7 show that the difference between the full and ebb tides is not as great as that of the first recording. Difference of Ma (1) ___ Mi (1) in the afternoon of the 21st is 0.341 M. compared to that in the forenoon of the 6th which was 0.76 M.

The third attempt was made at a place 30 M. south of Minatoguchi. A reinforced concrete shelter was built to house the tide guage as shown in Fig. 10. The rubber tube was inserted through steel pipe. The recording started at 1126 hrs, April 30th, and a continuous record for three days was obtained. The result is shown in Fig. 9 and Table 8.

B. The Well at Minatoguchi

An old well located approximately 50 M. east of Minatoguchi was used. The well is about 15 M. deep, and although the well water is not directly in contact with sea water, its rise and fall was nearly the same as that of the sea level.

Due to the suspected presence of poisonous gas (methane?) in the well and other hazards involved, we didn't investigate the inside of the old well. The result of the recording is shown in Table 9, and Fig 11.

C. Changes of Water Level within Bore Hole

The rise and fall of the water level in the drill hole was measured during the period from Dec. 7th to Dec. 29th. A continuous record was not obtained due to mechanical failure of the tide guage. The record from 0922 hrs., Dec. 9th to 0130 (?) hrs., Dec. 15th is rather complete. The author, therefore, shall mainly discuss the record obtained during that period.

The changes of water level in the drill hole, as Fig. 12 and Table 10 show, differ only slightly from those of the sea level.

Several attempts have been made to measure simultaneously the rise and fall of water level in the drill hole and that of sea level, but a satisfactory recording was not made. However, the rise and fall of the water level in the old well and that in the drill hole was recorded simultaneously from Dec. 14th to Dec. 19th. The record of the 14th and 15th is the most accurate. Therefore, the time of and the difference in time between full and ebb tides are compared as shown in Table 11. It seems that the time of the rise and fall of water level in the drill hole generally occurred later than that in the well and that of the ocean. As shown in Table 11, the difference in time at the two localities is 1 hour, 30 minutes for the 14th, and is 45 minutes for the 15th. Further study of the table reveals that the time of tides at the two localities are not necessarily fixed. Perhaps, the weather, atmospheric pressure, current, etc., at the time of recording account for the difference in time of occurrance of full and ebb tides at the two localities.

The record for 6 days, from the 14th to the 19th is shown in Table 12.

D. Water Level of the Pond.

There are many large and small ponds in Kita-Daito Zima. Oike, Akaike and Kamoike are the largest of them. Oike is connected to the sea by a cave, therefore, the rise and fall of the water level coincides with the sea level changes. We had thought of recording the changes of water level at Oike but abandoned the idea because of the number of days involved in clearing an area in order to install the tide guage. Akaike was chosen instead. Eight days extending from Dec. 22nd to Dec. 29th, were spent in recording the changes of water level, but only a slight difference was noticed. This difference may have been caused by rainfall of the previous day (Fig. 13).

VI ATMOSPHERIC TEMPERATURE

In order to determine the atmospheric temperature and pressure in the drilling area, a request was made to the staffs of the grammar school located in the central depression. The observation was carried out at 1400 hrs. daily; therefore, it is only natural that the temperature at dawn and dusk should be lower than the table indicates. In comparison with the coastal area, the temperature in the central basin is somewhat higher. The results are recorded ~~in Table 13~~ and are shown graphically in Fig. 14. The average temperature for each month is as follows:

November (11 days)	25.5° C
December	22.4° C
January	19.0° C
February	19.5° C
March	20.3° C
April	25.22°C

VII PRELIMINARY ANALYSIS OF CORES

It was learned that the cores recovered during the first boring differ greatly above and below 103 M. in depth, the former being dolomitic limestone, and the latter pure limestone. The core recovered from 226.52 - 229.52 M (sample number 848) and from 352.73 - 359.73 M. (sample number 881) in the second drilling were analysed by Noboru Ishikura.

No. 848:

The cores were somewhat cylindrical, and the pieces were about 4.5 cm. long. They were rounded at the edges by friction of the crown. Grayish white and generally hard. Appearance like a fine-grained sandstone. Contain bivalves.

No. 881:

The core is composed of 6 nodules measuring 38, 37, 30, 29, 25, and 25 mm in length. The smallest one was analysed. Whitish with a sandstone-like appearance. Generally hard.

The analyses of the two samples mentioned above are shown in the following table.

Sample number	848	881
Component		
Insoluble	0.06	0.79
Iron Oxide & Alumina	0.30	1.94
$CaCO_3$	98.46	94.98
$MgCO_3$	0.54	1.57
Total	99.36	99.28

Studying the above table, it is considered that the limestones penetrated in the second drilling may be pure limestone similar to that of the limestone below the 103 M. mark in the first drilling. Sample No. 848 from 226.52 - 229.52 M. has an extremely low $MgCO_3$ content.

A few reef-building corals, echinoid spines, calcareous algae, and shells were also analysed by Ishikura. They were:

1. Porites cf. tenuis Verrill
2. Pocillopora meandrina nobilis (Verrill)
3. Millepora tortuosa Dana
4. Serpula sp. with calcareous algae
5. Halimeda opuntia f. renschii Barton
6. Rhodopeltis borealis Yamada
7. Test of Echinometra mathaei (de Blainville)
8. Spines of Echinometra mathaei (de Blainville)
9. Drupa spathulifera (de Blainville)
10. Cyprea caputserpentis Linné
11. Asaphis dichotoma (Anton).

The analyses of the above are shown in Table 14. The numbers at the left of the table correspond to the above numbers. Those highest in $CaCO_3$ are mollusca, followed by reef building corals.

F. W. Clarke and W. C. Wheeler have made chemical analyses of marine invertebrates in the past. The species closely related to those mentioned above are shown in Table 15 for comparison with those from Kita Daito.

As table indicates, there is no conspicuous difference between the two, but the $CaCO_3$ and $MgCO_3$ content of the fossils collected from the Atlantic Ocean is greater than that of those collected from Kita-Daito.

END

DAIRY TABLE 1 PROGRESS

Date	Drilling time (in minutes)	Core recovery (in millimeters)	Daily progress (in meters)	Total depth (in meters)
Jan. 17 日	35	0	3.02	211.28
18	37	0	3.00	214.28
23	70	75	3.06	217.34
24	125	0	5.38	222.72
25	11	0	0.46	223.18
Feb. 1 日	5	0	0.34	223.52
3	74	226	3.00	226.52
5.	90	45	3.00	229.52
8	47	0	3.00	232.57
February 10	70	0	3.00	235.57
11	273	0	9.00	244.57
13	70	0	3.05	247.62
14	75	0	1.61	249.23
16	42	0	1.44	250.67
17	110	165	4.57	255.24
19	75	0	4.44	259.68
20	50	0	3.01	262.69
22	55	275	3.00	265.69
23	105	0	3.05	268.74
24	190	181	6.05	274.79
25	90	0	6.05	280.84
26	90	46	4.58	285.42
27	185	0	6.25	291.67
28	95	90	2.35	294.02
29	120	0	3.40	297.42
March 月 1 日	155	128	4.89	302.31
5	80	40	3.05	305.36
6	75	0	3.00	308.36
9	95	0	3.00	311.36
21	40	0	1.06	312.42
22	30	0	1.94	314.36
24	85	0	2.00	316.36
25	20	0	1.00	317.36
26	50	78	1.86	319.22
27	25	0	1.14	320.36
28	50	132	2.06	322.42
29	55	64	3.00	325.42
31	135	65	6.10	331.52
April 月 1 日	125	0	7.05	338.57
2	185	0	8.11	346.68
3	75	0	4.00	350.68
4	30	0	2.05	352.73
5	120	270	7.00	359.73
6	135	0	6.05	365.78
7	165	104	5.05	371.83
10	50	37	3.00	374.83
11	45	0	3.05	377.88
12	115	0	6.00	383.88
13	115	0	6.10	389.98
14	135	0	5.00	394.98
April 17	110	0	3.02	398.00
19	200	0	9.82	407.82
20	300	0	15.00	422.82
21	80	0	2.95	425.77
24	170	0	5.90	431.67

Table 2

Monthly Progress

	1 月 January	2 月 February	3 月 March	4 月 April
Total days 掘進日數	5	20	13	17
Time, in minutes 掘進時間（分）	278	1863	895	2155
Core recovery 岩芯採集量(m)	0.075	1.028	0.507	0.411
Thickness drilled 進尺累計 (m)	13.92	74.24	34.10	101.15

TABLE 4

Depth	Sample Number	
	Slime	Cylindrical Core
209.26—211.28	1	—
211.28—223.18	2—5	839—842
223.18—226.52	—	843—847
226.52—229.52	6	848
229.52—232.57	7	—
232.57—235.57	8	—
235.57—244.57	9—10	—
244.57—247.62	11	—
247.62—250.67	12	—
250.67—255.24	—	849—854
255.24—259.68	13—25	—
259.68—262.69	26—38	—
262.69—265.69	39—47	855—858
265.69—268.74	48—56	—
268.74—274.79	57—68	859—863
274.79—280.84	69—79	—
280.84—284.01	80—90	—
284.01—285.42	91—99	864
285.42—291.67	100—109	—
291.67—294.02	110—119	865—866
294.02—297.42	120—129	—
297.42—302.31	130—138	867—870
302.31—308.36	139—149	871
308.36—311.36	150—151	—
311.36—312.42	152—155	—
312.42—314.36	156—162	—
314.36—316.36	163—169	—
316.36—318.97	170—174	872
318.97— 22.42	175—178	873—876
322.42—325.42	179—184	877—878
325.42—331.52	185—190	879—880
331.52—338.57	191—199	—
338.57—346.66	200—207	—
346.68—350.68	208—217	—
350.68—359.73	218—220	881—886
359.73—365.78	221—225	—
365.78—371.83	226—234	887 888
371.83—374.83	235—241	889
374.83—383.88	242—246	—
383.88—389.98	247—253	
389.98—394.98	254—257	—
394.98—398.00	258—261	
398.00—407.82	262—265	—
407.82—422.82	266—276	—
422.82—425.77	277—280	—
425.77—431.67	281—283	—

TABLE 5
Temperature within Drill Hole

Depth in meters	Thermocouple Reading - mm.	Temperature °C
water level 0.44	0	22.50
10	3.0	21.60
20	6.0	21.00
30	8.0	20.10
40	10.0	19.85
50	12.0	19.35
60	13.0	19.10
70	14.0	18.85
80	16.0	18.38
90	16.5	18.30
100	20.0	17.30
110	21.0	17.10
120	22.0	16.80
130	24.0	16.30
140	24.0	16.30
150	25.5	16.00
160	26.0	15.80
170	27.0	15.55
180	29.0	15.05
190	30.0	14.80
200	32.5	14.20
210	34.0	13.75

Depth in meters	Thermocouple Reading - mm.	Temperature °C
220	35.0	13.50
230	36.5	13.20
240	37.5	12.85
250	38.5	12.60
260	39.5	12.00
270	41.0	11.95
280	42.0	11.70
290	43.5	11.40
300	44.5	11.10
310	45.5	10.85
320	46.5	10.55
330	47.5	10.30
340	48.0	10.15
350	49.0	9.95
360	50.0	9.70
370	51.0	9.50
380	52.0	9.25
390	53.0	9.00
395	54.0	8.75

更に是等の結果を圖示すれば下の如くになる.

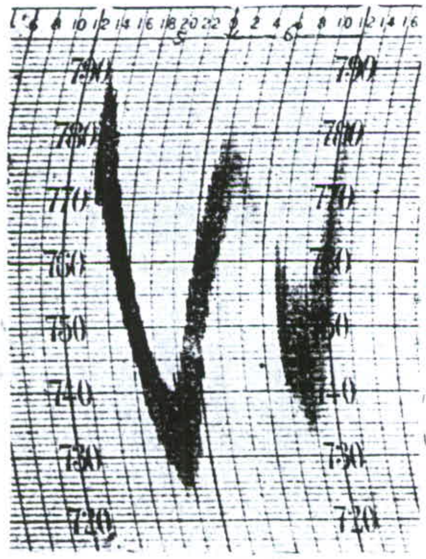


Fig. 7 - First tide gauge record at Minatoguchi

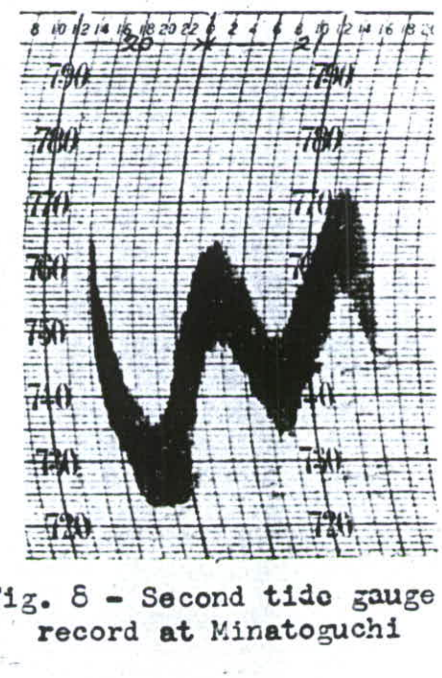


Fig. 8 - Second tide gauge record at Minatoguchi

TABLE 6
Tide Record at Minatoguchi

Dec. 5		Dec. 6		
$Ma_{(1)}$	$Mi_{(2)}$	$Ma_{(1)}$	$Mi_{(1)}$	$Ma_{(2)}$
1425 hrs.	2150 hrs.	0238 hrs.	1018 hrs	?

	R (mm)	H (m)
$Ma_{(2)}$ --- $Mi_{(2)}$	46	1.205
$Mi_{(2)}$ --- $Ma_{(1)}$	40	1.048
$Ma_{(1)}$ --- $Mi_{(1)}$	29	0.760
$Mi_{(1)}$ --- $Ma_{(2)}$	25 + a	0.655 + a'

$Mi_{(1)}$ First ebb tide
$Mi_{(2)}$ Second ebb tide
$Ma_{(1)}$ First full tide
$Ma_{(2)}$ Second full tide
R Reading on tide guage
H Difference between full and ebb tides

通りであ
なる.

TABLE 7
Second tide record at Minatoguchi

Dec. 20		Dec. 21			
$Ma_{(2)}$	$Mi_{(2)}$	$Ma_{(1)}$	$Mi_{(1)}$	$Ma_{(2)}$	$Mi_{(2)}$
?	2151 hrs.	0325 hrs.	0912 hrs.	1459 hrs.	?

	R (mm)	H (m)
$Ma_{(2)} \rightarrow Mi_{(2)}$	$24+\alpha$	$0.629+\alpha'$
$Mi_{(2)} \rightarrow Ma_{(1)}$	$26+\beta$	$0.681+\beta'$
$Ma_{(1)} \rightarrow Mi_{(1)}$	13	0.341
$Mi_{(1)} \rightarrow Ma_{(2)}$	33	0.576
$Ma_{(2)} \rightarrow Mi_{(2)}$	—	—

TABLE 8
Tide Record of a Place 30 Meters South of Minatoguchi

Date \ Tide	$Ma_{(1)}$	$Mi_{(1)}$	$Ma_{(2)}$	$Mi_{(2)}$
Apr. 30	?	?	1320 hrs.	2020 hrs.
May 1	02? hrs.	08? hrs.	1400 hrs.	2110 hrs.
2	0300 hrs.	1000 hrs.	1600 hrs.	2200 hrs.
3	0400 hrs.	1040 hrs.	?	?

	R(mm)	H(m)
$Ma_{(2)} \rightarrow Mi_{(2)}$	31	0.812
$Mi_{(2)} \rightarrow Ma_{(1)}$	30+	0.786
$Ma_{(1)} \rightarrow Mi_{(1)}$	?	?
$Mi_{(1)} \rightarrow Ma_{(2)}$	27?	0.707
$Ma_{(2)} \rightarrow Mi_{(2)}$	32?	0.838
$Mi_{(2)} \rightarrow Ma_{(1)}$	34	0.891
$Ma_{(1)} \rightarrow Mi_{(1)}$	35	0.917
$Ma_{(2)} \rightarrow Mi_{(2)}$	38	0.996
$Mi_{(2)} \rightarrow Ma_{(1)}$	41	1.074
$Ma_{(1)} \rightarrow Mi_{(1)}$	52	1.362

TABLE 9

Rise and Fall of the Water Level within the Well

Tide / Date	$Mi_{(1)}$	$Ma_{(1)}$	$Mi_{(2)}$	$Ma_{(2)}$
Dec. 14	?	1030 hrs.	1630 hrs	2150 hrs.
15	?	1142 hrs	1735 hrs.	2257 hrs.
16	?	1222 hrs.	1828 hrs	2349 hrs
17	0705 hrs.	1318 hrs.	1928 hrs.	--

Tide / Date	$Ma_{(1)}$	$Mi_{(1)}$	$Ma_{(2)}$	$Mi_{(2)}$
Dec. 18	0052 hrs.	0751 hrs.	1357 hrs.	2121 hrs
19	0243 hrs.	0859 hrs.	1505 hrs.	2310 hrs.
20	0450 hrs	?	?	?

		R(mm)	H(m)
14	$Ma_{(1)} \to Mi_{(2)}$	31	0.550
	$Mi_{(2)} \to Ma_{(2)}$	24	0.629
15	$Ma_{(2)} \to Mi_{(1)}$	$35+\alpha$	$0.917+\alpha'$
	$Mi_{(1)} \to Ma_{(1)}$	$30+\beta$	$0.786+\beta'$
	$Ma_{(1)} \to Mi_{(2)}$	19	0.498
	$Mi_{(2)} \to Ma_{(2)}$	20	0.524
16	$Ma_{(2)} \to Mi_{(1)}$	$31+\gamma$	$0.812+\gamma'$
	$Mi_{(1)} \to Ma_{(1)}$	$30+\delta$	$0.786+\delta'$
	$Ma_{(1)} \to Mi_{(2)}$	17	0.445
	$Mi_{(2)} \to Ma_{(2)}$	16	0.419
17	$Ma_{(2)} \to Mi_{(1)}$	25	0.655
	$Mi_{(1)} \to Ma_{(1)}$	28	0.734
	$Ma_{(1)} \to Mi_{(2)}$	17	0.445
	$Mi_{(2)} \to Ma_{(1)}$	13	0.341
18	$Ma_{(1)} \to Mi_{(1)}$	19	0.498
	$Mi_{(1)} \to Ma_{(2)}$	22	0.576
	$Ma_{(2)} \to Mi_{(2)}$	20	0.524
91	$Mi_{(2)} \to Ma_{(1)}$	11	0.288
	$Ma_{(1)} \to Mi_{(1)}$	12	0.314
	$Mi_{(1)} \to Ma_{(2)}$	20	0.524
	$Ma_{(1)} \to Mi_{(2)}$	22	0.576
20	$Mi_{(2)} \to Ma_{(2)}$	15	0.393
	$Ma_{(2)} \to Mi_{(1)}$	14?	0.367?

TABLE 10
Rise and Fall of the Water Level within the Drill Hole

Date \ Tide	$Mi_{(1)}$	$Ma_{(1)}$	$Mi_{(2)}$	$Ma_{(2)}$
Dec. 9	?	?	1244 hrs.	1847 hrs
10	?	0847 hrs.	1434 hrs.	1939 hrs.
11	0405 hrs.	0938 hrs.	1506 hrs.	2027 hrs.
12	0506 hrs.	1034 hrs.	1601 hrs.	2132 hrs.
13	0545 hrs.	1119 hrs.	1634 hrs.	2214 hrs.
14	0614 hrs.	1205 hrs.	1739 hrs.	2300 hrs.
15	0653 hrs.	1227 hrs.	?	?

		R(mm)	H(m)
9	$Mi_{(2)} \rightarrow Ma_{(2)}$	19	0.498
	$Ma_{(2)} \rightarrow Mi_{(1)}$	$39+\alpha$	$1.022+\alpha'$
	$Mi_{(1)} \rightarrow Ma_{(1)}$	$33+\beta$	$0.865+\beta'$
10	$Ma_{(1)} \rightarrow Mi_{(2)}$	18	0.471
	$Mi_{(2)} \rightarrow Ma_{(2)}$	22	0.576
	$Ma_{(2)} \rightarrow Mi_{(1)}$	43	1.127
	$Mi_{(1)} \rightarrow Ma_{(1)}$	37	0.969
11	$Ma_{(1)} \rightarrow Mi_{(2)}$	18	0.471
	$Mi_{(2)} \rightarrow Ma_{(2)}$	23	0.603
	$Ma_{(2)} \rightarrow Mi_{(1)}$	42	1.100
	$Mi_{(1)} \rightarrow Ma_{(1)}$	36	0.943
12	$Ma_{(1)} \rightarrow Mi_{(2)}$	17	0.445
	$Mi_{(2)} \rightarrow Ma_{(2)}$	22	0.576
	$Ma_{(2)} \rightarrow Mi_{(1)}$	41	0.074
	$Mi_{(1)} \rightarrow Ma_{(1)}$	35	0.917
13	$Ma_{(1)} \rightarrow Mi_{(2)}$	16	0.419
	$Mi_{(2)} \rightarrow Ma_{(2)}$	21	0.550
	$Ma_{(2)} \rightarrow Mi_{(1)}$	37	0.969
	$Mi_{(1)} \rightarrow Ma_{(1)}$	32	0.838
14	$Ma_{(1)} \rightarrow Mi_{(2)}$	16	0.419
	$Mi_{(2)} \rightarrow Ma_{(2)}$	19	0.498
	$Ma_{(2)} \rightarrow Mi_{(1)}$	33	0.865
15	$Mi_{(1)} \rightarrow Ma_{(1)}$	29	0.760

Table 11

Tide \ Date	14th	15th
Mi(1)	0640 hrs ?	0653 hrs ?
D_1	?	?
Ma(1)	1200 1030	1207 1142
D_2	1 hr 30 min	45 min
Mi(2)	1739 1636	? 1735
D_3	1 hr 03 min	?
Ma(2)	2300 2150	? 2257
D_4	1 hr 10 min	?

Underlined hrs : record taken at the old well.

D_1 D_2 D_3 D_4 : Difference of time of tides.

Table 12

Recording For 6 Days at the drill hole and old well.

		R(mm)	H(m)
14	$Ma_{(2)} \longrightarrow Mi_{(1)}$	33 **35 + α**	0.865 **0.917 + α′**
15	$Mi_{(1)} \longrightarrow Ma_{(1)}$	29 **30 + β**	0.760 **0.786 + β′**
	$Ma_{(1)} \longrightarrow Mi_{(2)}$	? **19**	? **0.498**
	$Mi_{(2)} \longrightarrow Ma_{(2)}$	? **20**	? **0.524**
	$Ma_{(2)} \longrightarrow Mi_{(1)}$	? **31 + γ**	? **0.812 + γ′**
16	$Mi_{(1)} \longrightarrow Ma_{(1)}$	? **30 + δ**	? **0.786 + δ′**
	$Ma_{(1)} \longrightarrow Mi_{(2)}$	15 **17**	0.394 **0.445**
	$Mi_{(2)} \longrightarrow Ma_{(2)}$	14 **16**	0.367 **0.419**
17	$Ma_{(2)} \longrightarrow Mi_{(1)}$	20 **25**	0.524 **0.655**
	$Mi_{(1)} \longrightarrow Ma_{(1)}$	23 **28**	0.603 **0.733**
	$Ma_{(1)} \longrightarrow Mi_{(2)}$	14 **17**	0.367 **0.445**
	$Mi_{(2)} \longrightarrow Ma_{(1)}$	11 **13**	0.288 **0.341**
18	$Ma_{(1)} \longrightarrow Mi_{(1)}$	17 **19**	0.445 **0.498**
	$Mi_{(1)} \longrightarrow Ma_{(2)}$	19 **22**	0.498 **0.576**
	$Ma_{(2)} \longrightarrow Mi_{(2)}$	17 **20**	0.445 **0.524**
	$Mi_{(2)} \longrightarrow Ma_{(1)}$	11 **11**	0.288 **0.238**
19	$Ma_{(1)} \longrightarrow Mi_{(1)}$	11.5 **12**	0.301 **0.314**

Five figures : in drill hole

Solid figures: in old well

Table 14

Analyses by Ishikura

成分 / Sample	Ig. Loss	$Fe_2O_3 + Al_2O_3 + P_2O_5$	$CaCO_3$	$MgCO_3$	Insoluble matter (SiO_2)	Total Sum
1	1.66	0.21	97.65	—	0.09	99 61
2	1.67	0.78	97.41	—	0.09	99 95
3	2.20	0.21	90.07	trace	0.08	99.56
4	3.81	0.11	86.38	9.41	0.11	99.82
5	16.64	0.14	82.88	trace	0.08	99.74
6	21.54	0.26	77.46	—	0.32	99.58
7	6.07	0.18	86.99	6.36	0.14	99.74
8	3.62	0.29	84.77	11.21	0.10	99.99
9	1.78	0.48	97.52	trace	0.12	99.90
10	0.91	0.52	98 46	trace	0.16	100.05
11	0	0.52	99.09	—	0.16	99.77

Table 15

Chemical Analyses of marine invertebrates

成分 / Species	SiO_2	$(Al, Fe)_2O_3$	$MgCO_3$	$CaCO_3$	$CaSO_4$	$Ca_3P_2O_8$
Porites furcata Lamarck (Fla)	0.12	0.11	0.82	99.95	?	trece
Porites clavaria Lamarck (Golding Cay)	0.04	0.10	0.37	99.49	?	trace
Porites astreoides Lamarck. (Golding Cay).	0.02	0.02	0.40	99.56	?	trace
* Porites cf tenuis Verrill	0.09	0.21	—	97.65	—	?

成分 / Species	SiO_2	$(Al, Fe)_2O_3$	$MgCO_3$	$CaCO_3$	$CaSO_4$	$Ca_3P_2O_8$
Millepora alcicornis Linné (Tortugas)	0.24	0.11	0.95	98.22	0.48	trace
Millepora alcicornis Linné (Bermuda)	0.02	0.07	0.22	99.63	0.06	trace
Millepora braziliensis Verrill (Brazil)	0.09	0.21	1.28	98.22	1.80	trace
* Millepora tortuosa Dana	0.08	0.21	trace	97.07	—	?

* 北大東島産

From Kita Daito

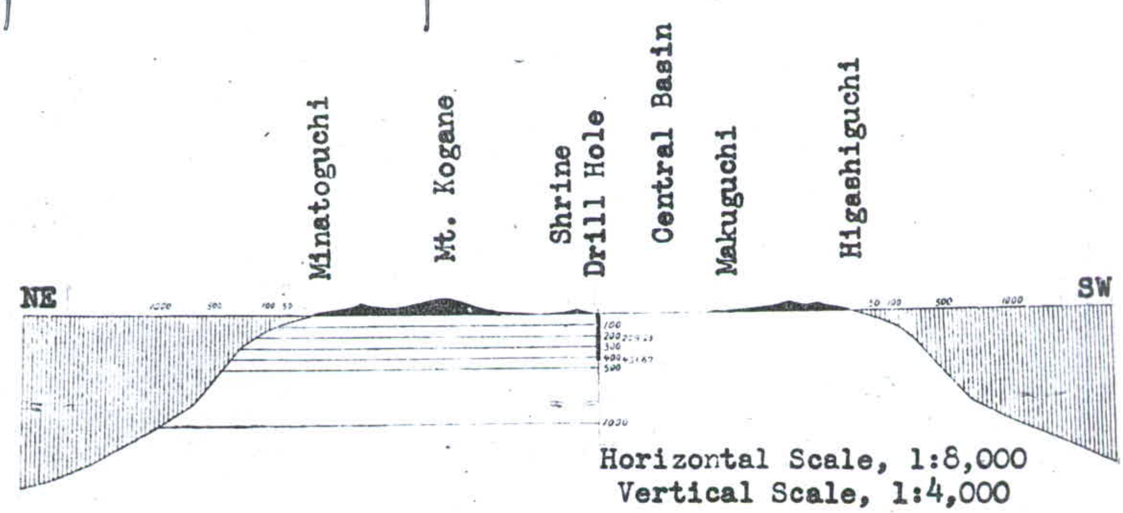


Fig. 4 - Cross-section through Kita Daito-Zima

第 5 Section of ~~bore~~ drill hole

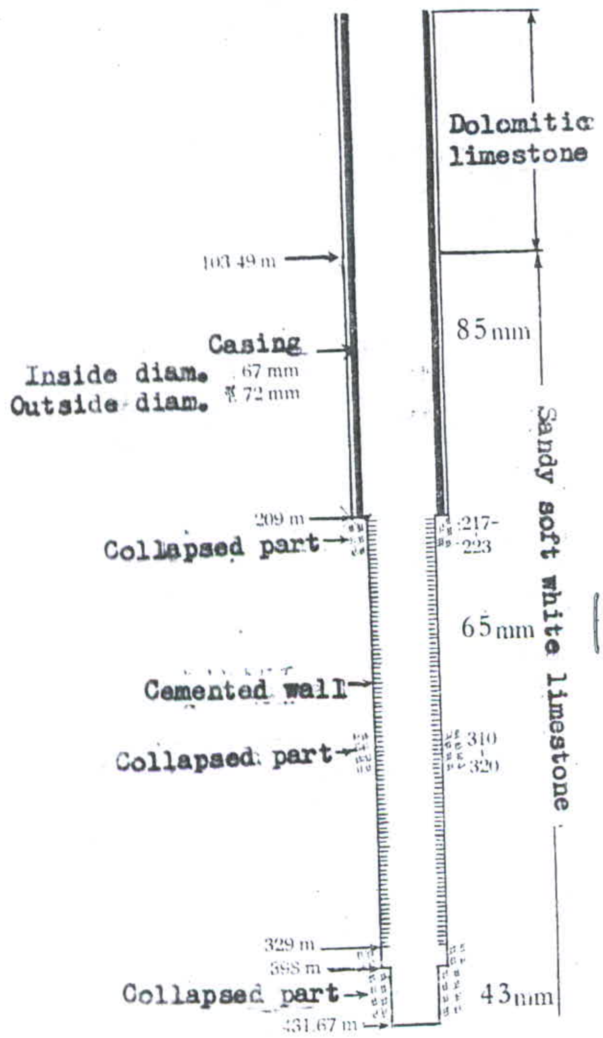
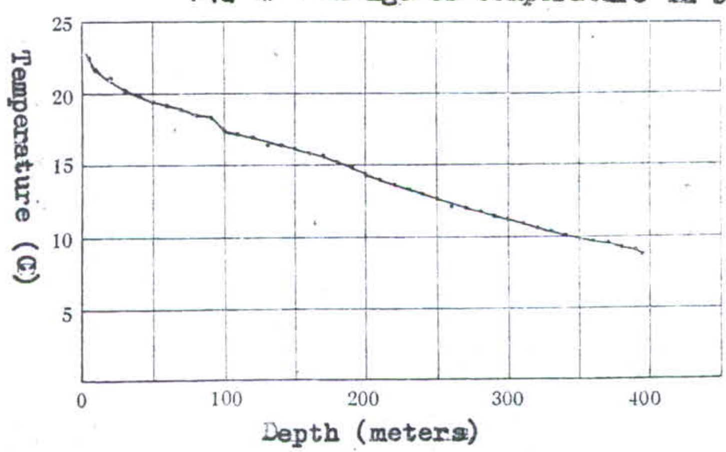


FIG 第 6 Change of temperature in bore hole.



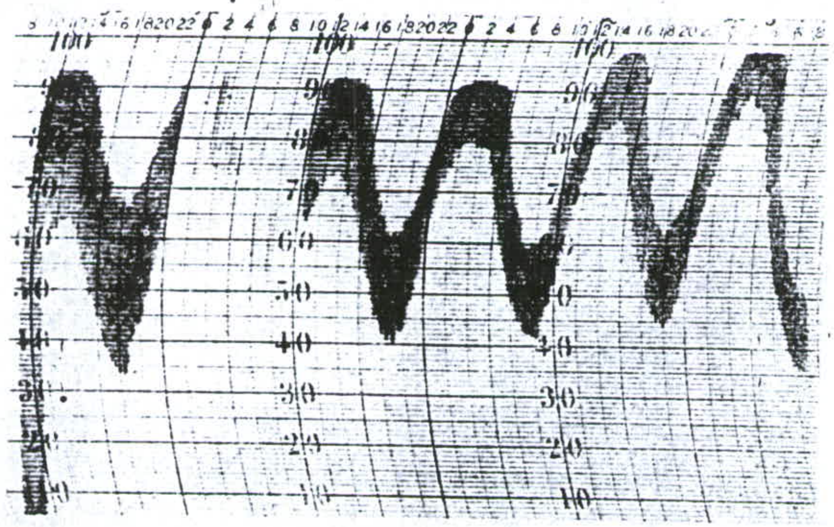
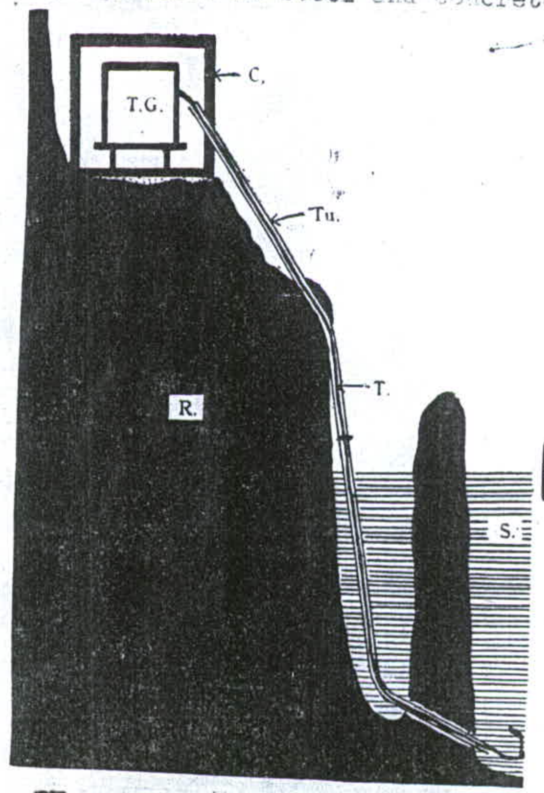


Fig. 9 - Tide gauge record measured at a place 30 meters south of Minatoguchi

FIG 第 10 圖

Tide gauge based in steel and concrete



TG-Tide gauge. TU-steel tube. T-rubber tube. S-sea
R-limestone

Fig. 11 Tide gauge record measured at well at Minatoguchi.

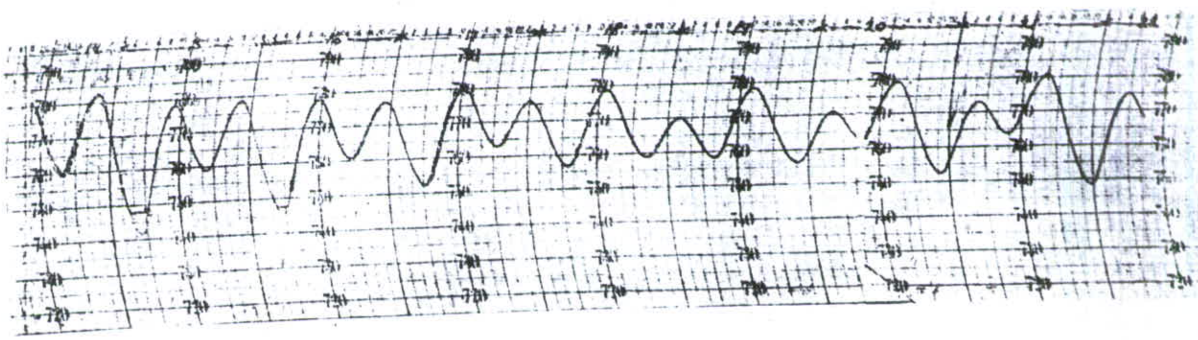


FIG 第 12 Tide ~~gauge~~ record measured in drill ~~…e~~ hole

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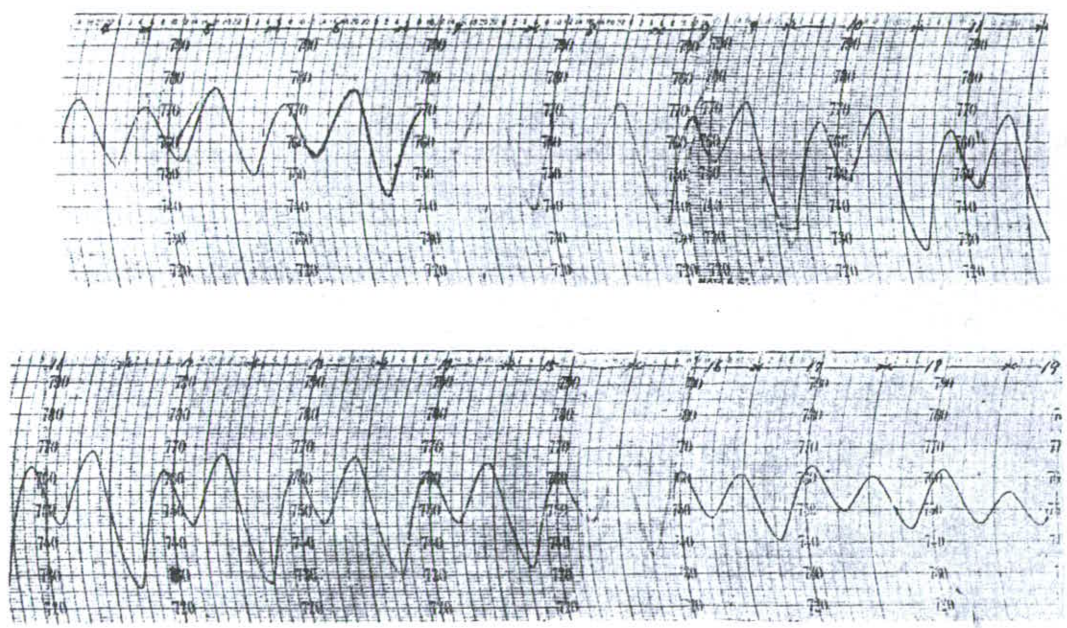


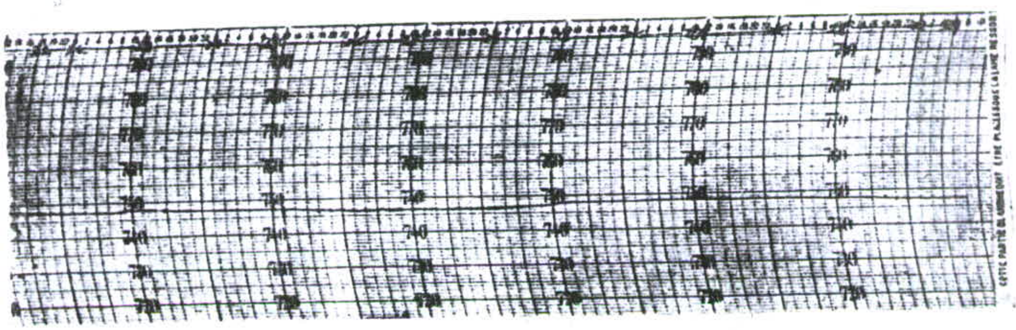
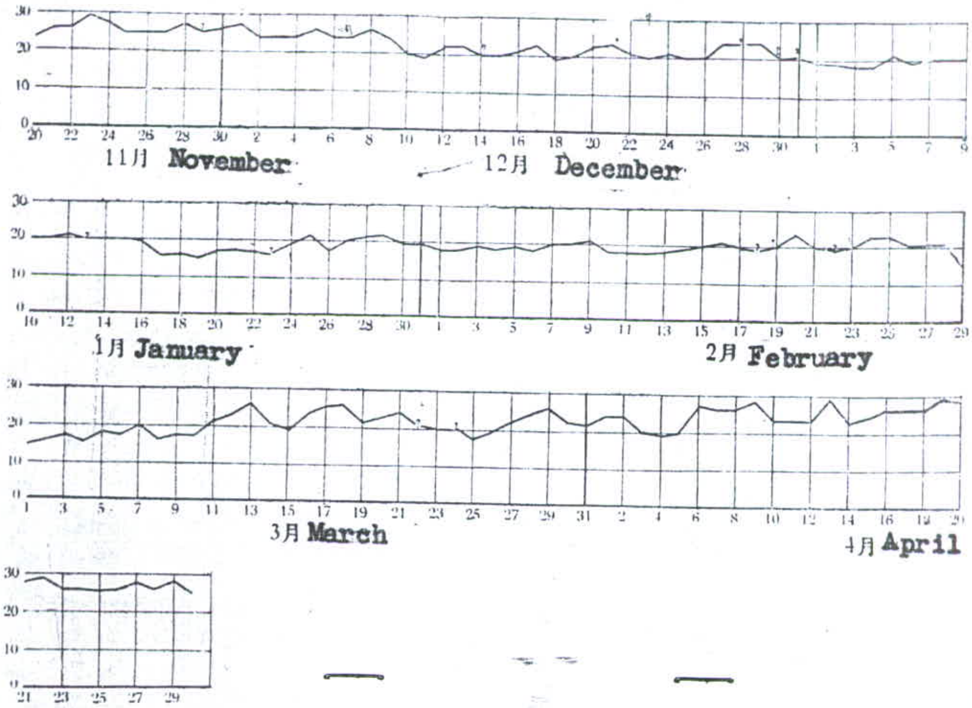
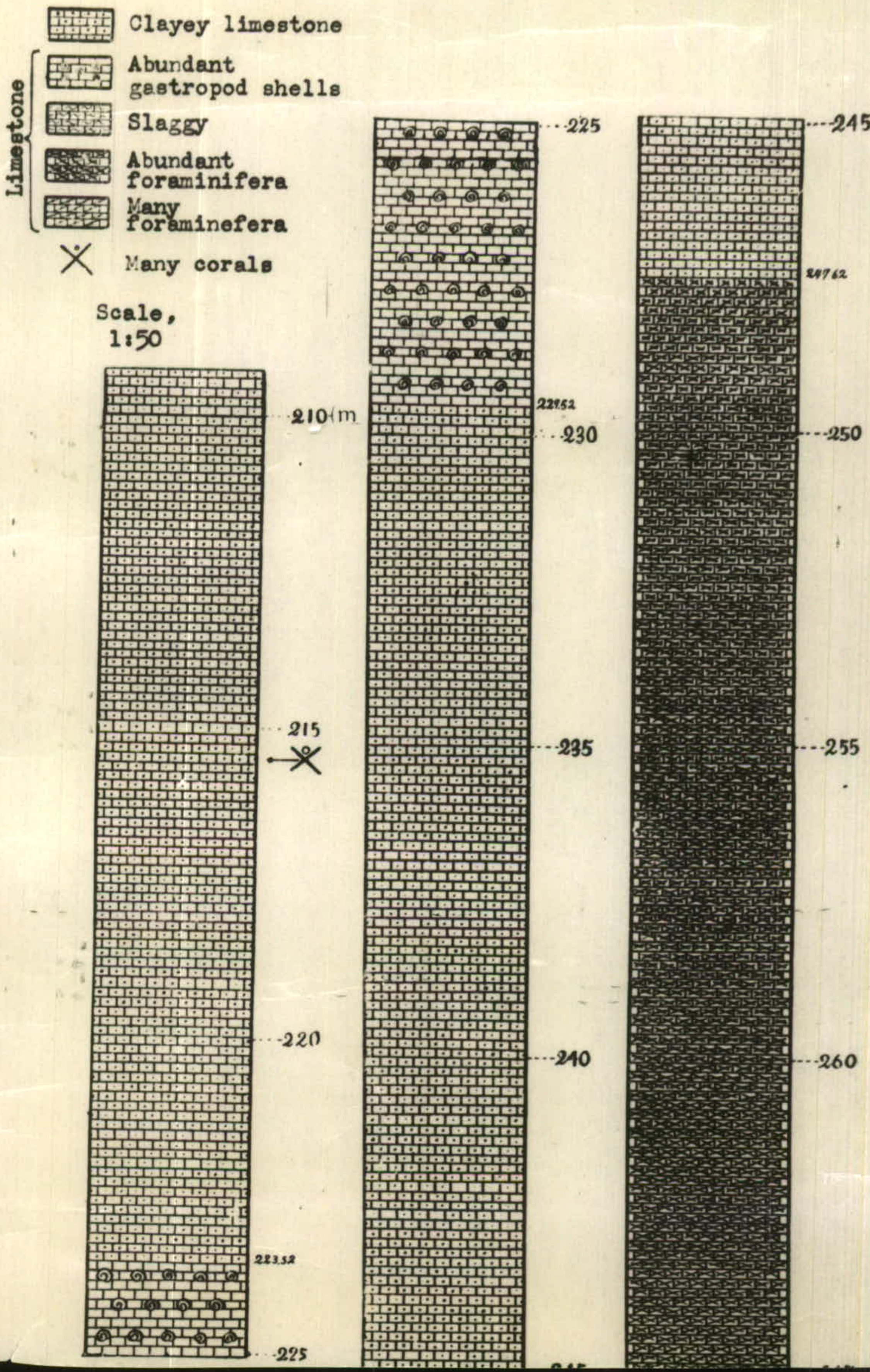


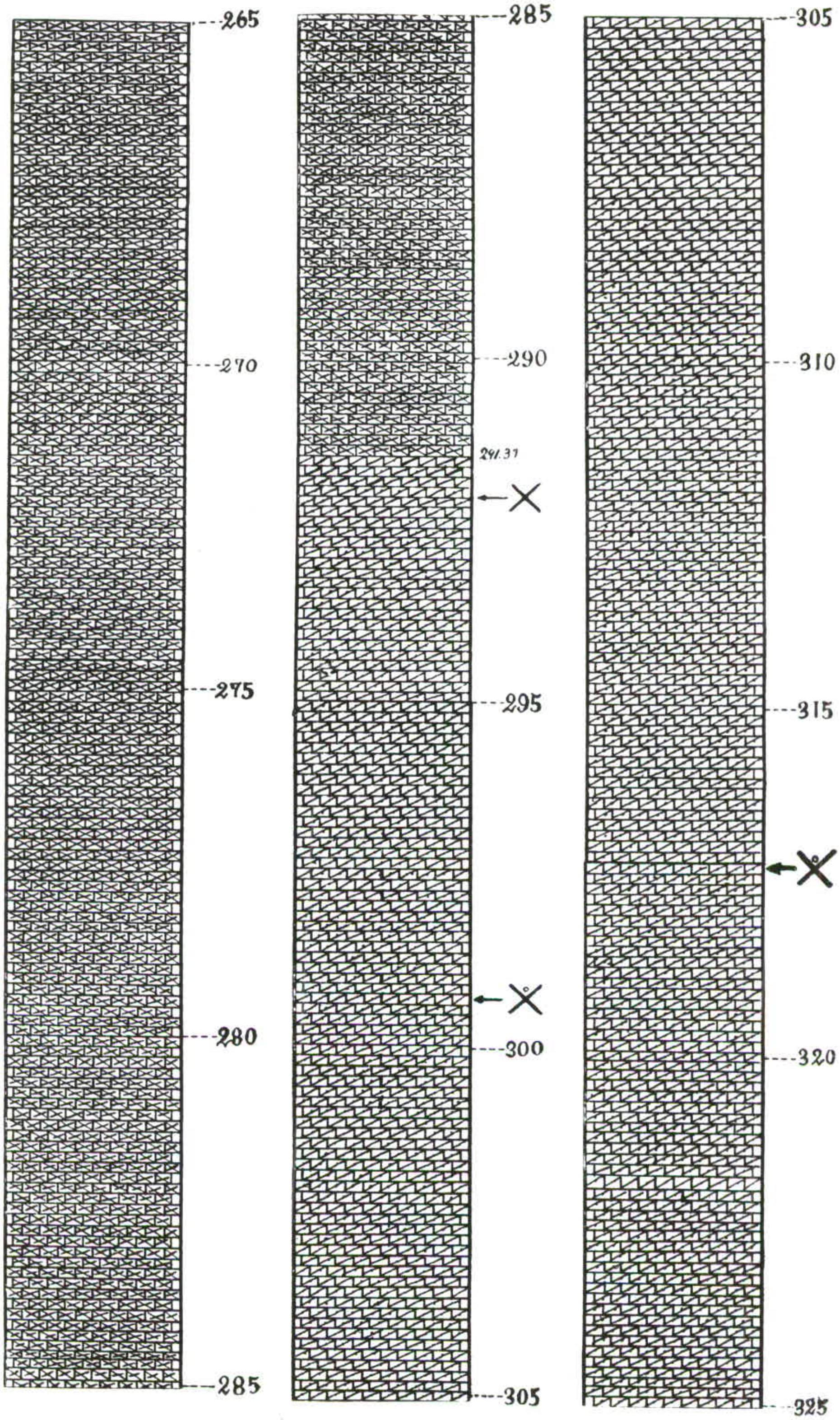
Fig. 13 - Tide gauge record at Akaike Pond

FIG 第 14 Change of temperature in central basin



COLUMNAR SECTION OF THE SECOND DEEP DRILLING ON KITA DAITO-ZIMA

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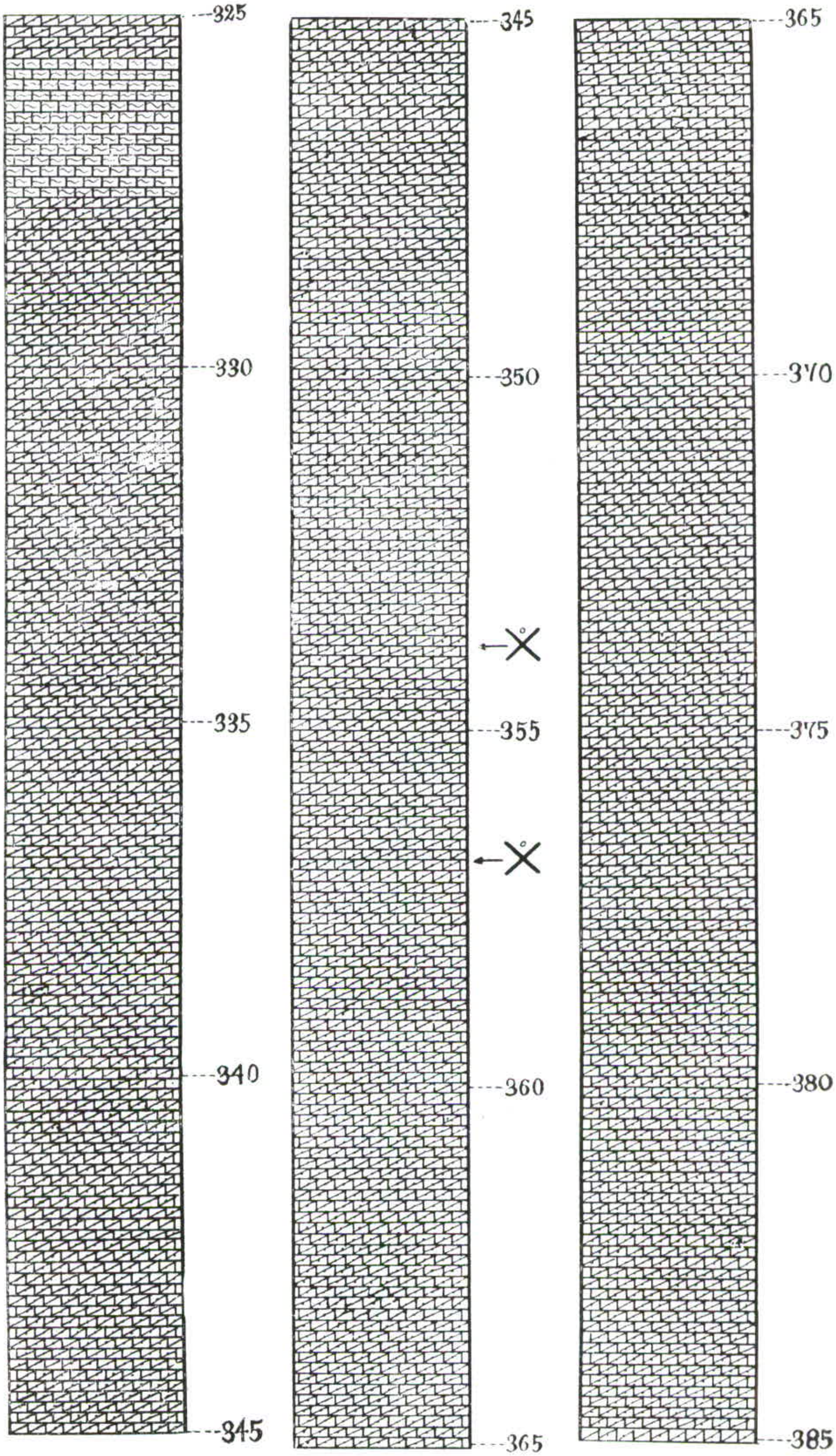

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380
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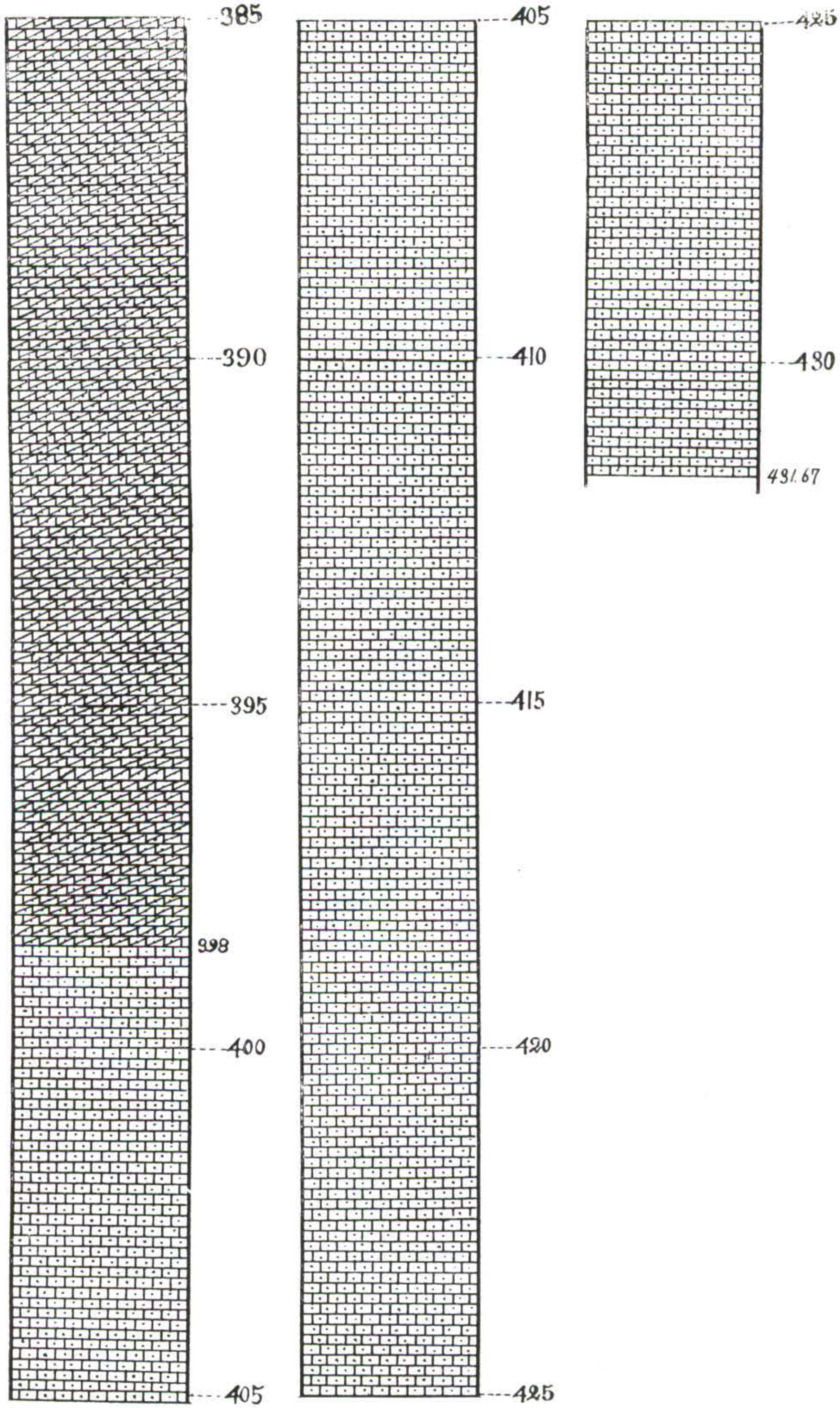


385
390
395
398
400
405
405
410
415
420
425
425
430
431.67

Plate I

Fig. 1. The tide guage in Minatoguchi Harbor.

Fig. 2. Building a reinforced concrete shelter at the shore cliff, about 30 meters south of Minatoguchi.

Fig. 3. Setting up the tide guage in the shelter.

Fig. 4. Setting up the tide guage in the old well (15 meters in depth) drilled on Sotomaku (Gaihagu) coral reef at Minatoguchi.

第 I 圖 版

(1)

(3)

(4)

(2)

Plate II

Fig. 1. Removing a monument built in commemoration of the first Kita Daito-Jima boring for the purpose of setting up tide guage.

Fig. 2. Tent sheltering the tide guage set up on the drill hole.

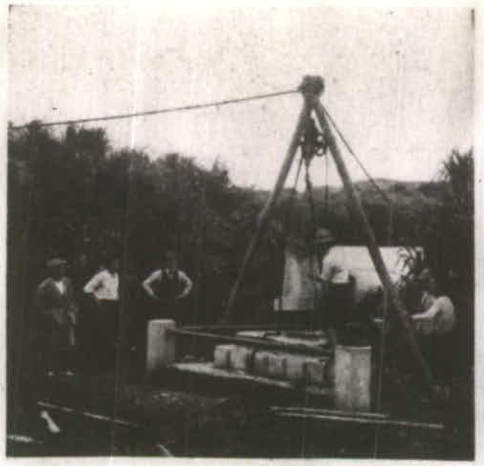
Fig. 3. A purification ceremony just before spuding in.

Fig. 4. Insertion of casing.

Fig. 5. Attaching swivel to the drill rod.

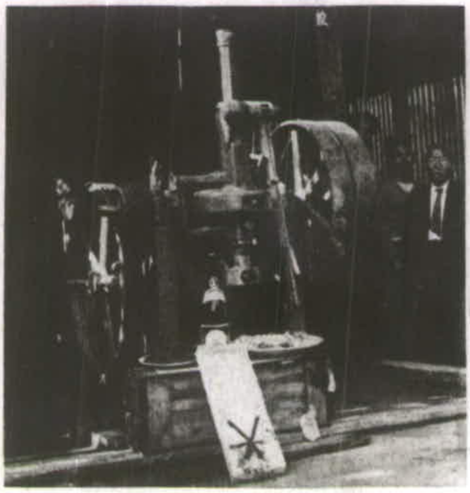
Fig. 6. Drilling with a balance weight.

第 II 圖 版



(1)

(2)



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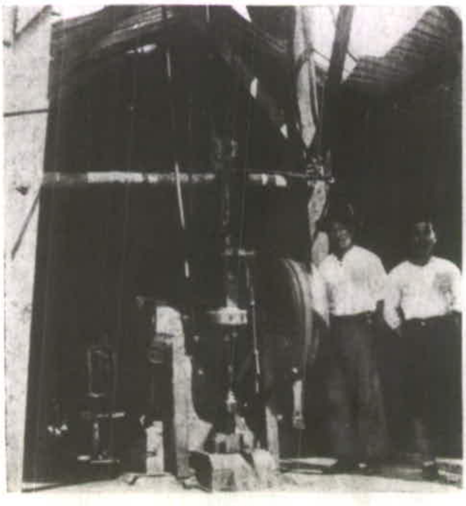

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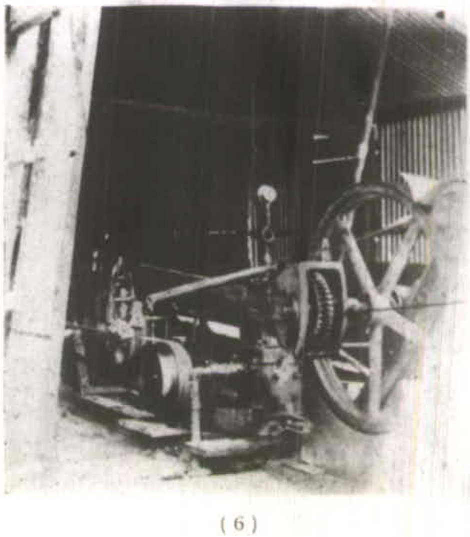

(6)

Plate III

Fig. 1. Tenguiwa, a rock looking like a long nosed goblin, on the east coast.

Fig. 2. Commanding a view of Rappakujira in the west from Sotomaku (Gaihagu) Ridge at Kitaguchi.

Fig. 3. Uchimaku (Uchihagu) Ridge east of Nankinkujira. Note bedded strata.

Fig. 4. Close-up of coastal beds at Jorikuguchi. Undulating layers are reef-building corals.

Fig. 5. Boulder at Makugami (Hagugami) west of Tenguiwa. Composed of Galaxea.

第 III 圖 版

(1)

(2)

(3)

(4)

(5)

Plate IV

Fig. 1. North coast between Kurobeko and Kitaguchiko. Undulating layers are reef-building corals (Porites).

Fig. 2. Sotomaku (Gaihagu) coral reef of the Kitaguchi Coast. Bedded strata are mainly Acropora colonies.

Fig. 3. Detail of Fig. 2, Acropora colonies.

第 IV 圖 版

(1)

(2)

(3)

Plate V

Fig. 1. Inner side of Kita-Uchimaku (Kita-Uchihagu) Acropora in normal growing position.

Fig. 2. Core from 262.69 to 265.69 meters in depth. X 20/23.

Fig. 3. Foraminifera from core collected from 259.44 to 262.45 meters. (Mainly Linderina).

第 V 圖 版

(1)

(2)

(3)

no. 308

TOPOGRAPHY, GEOLOGY AND CORAL REEFS
OF ROTA ISLAND

By

Sho SUGAWARA

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Tohoku Imp. Univ. 1934 1939(?)

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Translation edited by B. MORIWAKI April 1951

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Pacific Geological Surveys
Military Geology Branch, U.S.G.S.
Tokyo, Japan

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ILLUSTRATIONS

(At end of translation manuscript)

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TOPOGRAPHY, GEOLOGY, AND CORAL REEFS
OF ROTA ISLAND

By
Sho SUGAWARA

(I) INTRODUCTION

Under the guidance of TAYAMA, I investigated the topography and geology of Rota Island during the summers of 1937 and 1938. I was a member of a party investigating mineral resources in the South Sea Islands. My investigation is a continuation of TAYAMA's studies which were made in detail on the topography and geology of Rota Island.

The party would like to express grateful thanks to Dr. YABE for his guidance, the personnel at the Geological Institute of Tōhoku University, to the members of the Rota sub-branch of the South Sea Island Government, and to the members of the Rota Sugar Refinery, Nanyō Kōhatsu K. K. (South Sea Development Company).

The party is also much indebted to HANZAWA, ASANO (bachelor) and HATAI (assistant) who undertook the difficult problem of fossil determination. The writer is also grateful to TAYAMA, under whose actual guidance the present paper was completed.

(II) TOPOGRAPHY

A. Geographic Location.

The grid coordinates of Rota Island are: $14^{o}7'$-$13'$ lat. N., $145^{o}8'$-$18'$ long. E. The island of Aguijan, 80 kilometers to the northnortheast, and Mt. Tapotchau on Saipan can be observed from Rota Island [see Fig. 1]. Guam is located 60 kilometers to the southsouthwest of the island. Rota is aligned along the general NNE-SSW trend and is 20 kilometers long and 7 kilometers wide, attaining a height of 496.4 meters. It looks like a beautiful step-like island from a distance.

B. Terraces.

Terraces are well developed on Rota [Plate I]. The terrace cliffs, consisting mainly of limestone and some agglomerate, are so prominent as to attain 100 meters in relative height. The cliffs dwindle in height and disappear. The relatively high and discontinuous terrace cliffs divide 6 levels. Some of them are also subgrouped into several smaller ones:

		Elevation range
I. Sabana terrace (470 meters)	Upper level	470-460 meters
	Lower level	460-420 "
II. Aburataruga terrace (420 meters)	Uzuranfauro level	420-370 "
	Aburataruga level	380-300 "

		Asrosariya level	300-240	meters
		Asyakeros level	260-220	"
III.	Shinaparu terrace (200 meters)		200-140	"
IV.	Lugi terrace (150 meters)	Lugi level	150-100	"
		Benakan level	100-60	"
V.	Taragaja terrace (60 meters)	Taragaja level	60-20	"
		Teruson level	20	"
VI.	Mirikattan terrace (5 meters)	Sonson level	5	"
		Mirikattan level	3	"

I. Sabana terrace (470-420 meters). Sabana terrace, the highest on the island, is a wide plateau developed around Mt. Manila which is a dome situated in the north central part of the plateau. Mt. Manila rises 30 meters above Sabana terrace and 496.4 meters above sea level. Sabana terrace is surrounded by limestone hills, Iisan and Hirosuyaccot, each about 20 meters high. Between these domes there extends a low area zone. As a whole the terrace is tilted southeastward descending to 420 meters in elevation. A gentle slope extending from Asfantango (475 meters alt.) to the spring at the farm divides the terrace into two areas. The lower area is about 60 acres.

II. Aburataruga terrace (420-220). The terrace developed

east and west of Sabana terrace is distinctly bounded by a fault scarp about 50 meters high. The eastern part is divided into 3 sub-levels. The first, Uzuranfauro level, situated at the northern side of Sabana terrace at 370 to 420 meters, dips northeastward. The second level, Aburataruga (380 to 320 meters high), situated at the eastern end of Uzuranfauro level, gently dips eastward. A gentle slope at the northwestern end connects Aburataruga level with Uzuranfauro. Furthermore near Chego north of the Uzuranfauro level, there are small flat areas at about 330 meters. The third level, Asrosaria at 300 to 240 meters alt. connects with the eastern border of Aburataruga level by a small slope, but in a gentle slope northeastward terminates in a precipice more than 30 meters high.

The western part of Aburataruga terrace is divided into 2 areas, Asyakeros level and Iisan. The latter is subdivided into the upper [3], middle [4] and lower [5] where the upper (360 to 390 meters high) tilting southwestward, is connected with the middle, which (300 to 360 meters high) in a triangular form rises slightly at the western edge while at the northeastern corner it is bounded by a fault scarp 40 meters in height. The lower level (280 to 300 meters high) where a cocoa company is situated is distinctly divided in the middle and is wide in the northern part. The Asyakeros level (220 to 260 meters) situated northwest and southwest of the Iisan levels is connected by fault scarps more than 30 meters high with terraces above and below. A small flat area (390 to 420 meters alt.) rich in fissures near an

footnote:
* Numbers in brackets refer to units on Plate I.

intermediate stop of Teruson aerial tramway at the northwestern edge of the terrace, those on the upper (280 to 300 meters high) and the middle levels (180 to 240 meters) at Hirippo all belong to Aburataruga terrace (II) group.

III. Shinaparu terrace. The largest terrace is well developed in eastern Shinaparu. The surface at 200 meters alt. is gently rolling, high to the north, and gently inclined along the perimeter. The small areas Fusudorina (140 to 160 meters high), Abu (150 to 180 meters high), Rimpanai (160 to 220 meters high), Hirippo (160 to 200 meters high) and Parie (140 to 200 meters high) around Aburataruga terrace (II) are all a part of Shinaparu terrace.

IV. Lugi terrace. Lugi terrace (100 to 150 meters alt.) adjoins the northeastern part of Shinaparu divided by fault scarps about 20 meters high. A low area zone is observed at the boundary.

In the western area the Lugi level is surrounded by a narrow but distinct terrace cliff. This level surface at 100 to 120 meters alt. near Rasgya is followed by terraces at 60 to 100 meters alt. near Benakan and Aan.

In Siyasaja area on the northern slope the terrace boundary is difficult to distinguish since the terrain gradually decreases from 60 meters altitude. In the southern area the Taihanom terrace is

at 110 to 140 meters alt. in the western corner. The terrace reappears east of Parie after an interval and below is bounded by a precipice about 40 meters high. Near the middle part of the precipice we can see occasionally a group of small level surfaces about 80 meters in height. Further east at the southern margin of Shinaparu terrace are small narrow level surfaces at 100 to 120 meters, 80 to 90 meters and 60 to 70 meters, respectively.

On Taipinkoto Peninsula, there are three terraces: 60 to 100 meters, alt., 100 to 120 meters alt. and 140 meters alt. The upper terrace is flat and of Karren topography while the middle and lower dip towards the sea.

V. Taragaja terrace. The island is encircled by Taragaja terrace which is about 20 meters high. A settlement at Sonson and a plant at Teruson are situated on this terrace. It rises to about 60 meters near Taragaja along the southern coast while on the northern slope east of Tatacho the boundary adjoining Lugi terrace is very indistinct. The precipice at the western margin of Benakan level divides into two. The level at the top of the lower precipice is the same as the upper surface of Taragaja.

VI. Mirikattan terrace. This terrace is about 5 meters high at Sonson town and along the northern coast at Tatacho and Teteto.

Lower levels 1 to 3 meters high at Anzota and Mirikattan are also found at Kuajwan, the eastern extremity of the island.

C. Coast Topography.

A remarkable contrast in topography is observed on both sides (southern and northern) in plan and elevation [Plate II]. Except small coral islands Anzota and Mirikattan at the northeastern corner, the northern coast is a straight, exceedingly monotonous sand beach from which gentle limestone slopes rise. On the other hand, except for a small sand beach west of Aueniya all the limestone precipices along the southern coast extend into the sea and below them abrasion terraces and inlets have been developed. Compared with the northern coast it is quite irregular and many small curvatures can be seen, especially in Tosa Bay. Sosanjaya Bay is bordered by Taipinkoto Peninsula at the western extremity. The notch below the precipice north of Taipinkoto peninsula is divided into two terraces: the upper is as high as Anzota and Mirikattan while the lower is as high as the upper surface of the present coral reef. The north and south coasts of the present island are divided into two notches which are as high as these two.

D. Drainage System.

Several streams on the southern slope originate at the boundary

between agglomerate and limestone at about 300 meters alt. below the southern cliff of Sabana terrace [see Plate III]. They are generally about 1.5 kilometers long and have deeply eroded the older limestone, connecting a number of valleys on agglomerate. The river running southward from a limestone cave at Sonson spring is relatively large. Streams are not found in the exposed agglomerate on the northern slope, but much water gushes out along the coast between Tatacho and Sonson. The salinity in a well along Mochon coast is exceedingly low. Along the coast east of Ponia, mineral springs seem to exist.

E. Limestone Caves.

Limestone caves are found at Sonson spring, below the precipice west of Hirippo, Sonson, and several other spots. The limestone cave at Sonson spring is 5 meters wide and 10 meters deep and is situated at the contact point of agglomerate and limestone at 350 meters. The water supply is abundant there. The second limestone cave, at a higher elevation, is more shallow. Only a small quantity of water is observed. The third, the largest, lying at the 50 meter level and rising in the interior opens in three directions with another name "Shin-i-to". Other limestones, east of Tatacho Church and at Finadepo (these two 10 to 20 meters high) are likely to extend in

the interior though they have a narrow entrance. Small-size caves are also found below the southern cliff at Ganpaapa and the northern cliff at Uzuranfauro.

F. Karst topography.

Limestones are exposed almost all over the island except in the low area at Lugi which is abundant in terra rosa (red-brown clay). Conditions are quite different from those on Saipan and Tinian. The marine terrace south of Taipinkoto, upper terrace of Taipinkoto and the eastern margin of Sabana Terrace are all abundant in fissures and may be called a Karren topography. Small depressions several meters in diameter are found at the northeastern corner of Iisan terrace near Uzuranfauro and south of Tatacho. This may be regarded as an example of "doline" but is of no significance.

(III) GEOLOGY OF ROTA ISLAND

The stratigraphic sequence on the present island is as follows:

1. Recent limestone.
2. Mirikattan limestone.
3. Raised beach deposits. [Order is as written by SUGAWARA].
4. Rota limestone.
5. Mariana limestone.
6. Ponia limestone.

7. Hirippo limestone.

8. Taihanom limestone.

9. Mariiru limestone.

10. Manila agglomerate.

A. The Stratigraphy by Areas.

1. Hirippo area.

The cliff west of Pēpo [see Plate III and Fig. 2a]: At the end of the agglomerate west of Pēpo there is a small cliff consisting of Mariiru limestone. The agglomerate is overlain by the limestone, the lower part containing whitish and reddish andesite gravel while the upper part is made up of yellowish sandy limestone and black gravelly limestone (black owing to Mn content). The cliff is, as a whole, gently inclined southsoutheastward with a thickness of 15 meters [thickness seems to refer to the black gravelly limestone]. Camerina is contained in the upper Mn bearing limestone.

The cliff east of Hirippo [Fig. 2b]: Away from the agglomerate outcrop, the cliff is connected in the south with the cliff west of Pēpo. The base, consisting of red-brown sandy limestone with inclusions of andesite gravel, is covered by white limestone containing a number of andesite gravel-bearing Camerinas. It is overlain by a thinly stratified blue-black limestone, white non-stratified coral andesite, thickly stratified yellow sandy limestone, and a thick gravelly limestone black

with Mn. The latter also contains Camerina. These are all part of the Mariiru limestone which is about 40 meters thick. The dip and strike are 15° S.E. and N. 65° E., respectively. Over the Mn limestone there is a stratified white sandy Hirippo limestone whose base is conglomerate. North of the cliff a blue-black conglomerate covers the lower Mariiru limestone.

The cliff west of Haofuniya [Fig. 2c]: The cliff is parallel to the eastern Hirippo cliff. A white coral limestone outcrops at the base of the eastern cliff of Hirippo, covered by a brecciated red limestone. Southward there is a yellow sandy limestone (Taihanom limestone) 30 meters thick and tilted southward. Further to the south is red sandy Hirippo limestone overlain by Ponia limestone.

The cliff west of Hirippo [Fig. 2d]: At the northern extremity of a paddy field immediately below the western cliff there is an outcropping of Taihanom limestone containing Borelis pigmeus. Farther southward is a small exposure of agglomerate overlain by white Mariiru limestone containing andesite gravel. The limestone is overlain by red sandy Hirippo limestone which looks like a reddish-white Cascajo limestone. At a higher part of the road southward the Hirippo is covered by white, coarsely stratified Ponia limestone.

The cliff is formed mainly of Hirippo limestone which is

about 40 meters thick and strikes N. 70° E. and dips 10° southward. The lower part consists of reddish-white relatively solid limestone and yellow tuffy limestone, while the upper is white or red sandy limestone. To the south and in the middle of the cliff Hirippo limestone is overlain unconformably by Ponia limestone, which consists of coarse grained limestone and conglomerate. Ponia limestone at the northern end of the cliff above the paddy field strikes E-W and dips 20 degrees southward.

Conglomeritic limestone is observed in the east side of the limestone cave below the northern precipice, and limestone, gravelly tuffy sandstone overlain by conglomerate in the northwestern side. These are all a part of the Taihanom limestone.

The cliff west of Taihanom [Fig. 2f]: At the northern extremity the agglomerate is overlain by Mariiru limestone which is about 60 meters thick and dips and strikes 15°S.E. and N. 80° E., respectively. The lower part consists of andesite gravel-bearing limestone, thinly stratified shaly limestone, white massive limestone, and yellow sandy limestone over which there is an alternation of mudstone and limestone, and light red limestone. Farther south Taihanom limestone, red sandy or yellow sandy in character, and frequently a tuffy brown limestone, is overlain by white Ponia

limestone tilting about 10 degrees southward and striking E-W.

Gagane cut [Fig. 2e]: There is a good exposure of limestone at the railway cut [south of Teruson]. A fault divides the northern agglomerate from the Mariiru limestone to the south. The limestone strikes N. 60° W. and dips 30° S.W., respectively. Overlying deposits probably belonging to the Taihanom group, successively from older to younger, are calcareous sandstone, white coral limestone, black gravelly limestone (Mn) containing Camerina, an irregular contact and a mudstone, another mudstone, limestone with a trace of Mn and containing Camerina, and thick tuffy mudstone.

Teruson cut: At the Teruson cut Taihanom limestone is exposed, overlain by Mariana limestone. In the southern area the lower part is conglomeritic in character and blackish due to the Mn content. Along the coast below the cut an exposure of agglomerate is covered by red gravelly limestone which grades to sandy.

Gagane coast: Along the Gagane coast south of Teruson cut there is a well-preserved exposure of Rota limestone, about 10 meters thick at the northern end. Close to the coast a recent limestone is tilted to the sea 5 to 10 degrees. Over the upper agglomerate there is a conglomerate containing Discocyclina which is also overlain by a white stratified marlaceous limestone with dip and strike 30° S.W.

and N. 40° W., respectively. Taihanom limestone is developed as far as Ponia promontory with strike and dip of N. 30° W. and S. 30°, respectively; the limestone is cut by several faults. This formation is mainly white limestone, but at the northern end, which is supposedly lower, it consists of calcareous sandstone and marlaceous limestone and at Ponia promontory it is also calcareous sandstone and contains innumerable slip faults. At an area which juts out along the middle of the coast, Taihanom limestone is overlain nonconformably by Ponia limestone whose dip and strike are 20° S.W. and N. 20° W., respectively.

2. Mariiru area.

At the base of a cliff about 30 meters high along the coast there is a small exposure of agglomerate overlain by white or yellow sandy Ponia limestone. In the middle there is yellow or red Globigerina sandstone containing limestone gravel (5 to 10 cm. in diameter) and the gravel in turn contains Miogypsinoides which belongs to Taihanom limestone. The stratigraphical relationship with Ponia limestone, however, is unknown.

The lower part of the cliff west of the locality consists of Mariiru sandstone, sandy or conglomeritic in character. It is overlain by stratified, white sandy Ponia limestone, the limestone being tilted southwestward. Cross-bedding is developed in the limestone.

Tuff is found in the middle of the agglomerate. Over the surface of the cliff is a Foraminiferal sandstone composed of a yellow _Globigerina_ sandstone and black _Miogypsinoides_ sandstone. The upper white Mariana limestone includes some limestone containing yellow sandy _Camerina_, the former being Taihanom and the latter Mariiru. In the higher areas there is an exposure of agglomerate and to the east massive red Tanohaim limestone containing _Spiroclypeus_.

3. Parie area.

Along the coast there is a small exposure of agglomerate covered by white stratified Ponia limestone, white conglomerate, white non-stratified Mariana limestone, and conglomerate containing red limestone pebbles. To the west there is a small exposure of tuff.

[A stratigraphic correlation of formations by areas is shown in Fig. 37.]

B. Geology of the Formations.

1. Manila agglomerate.

The underlying bedrock is an andesitic agglomerate and also forms Mt. Manila rising in the center of the highest terrace, the Sabana. This agglomerate outcrops below cliffs north and south of the terrace. It also occurs, in small patches, below the cliff southwest of Taipinkōto and Parie and Mariiru areas. The andesite in these

areas is mainly two-pyroxene andesite, sometimes hypersthene- and augite-andesite. In the southern slope the agglomerate is stratified and dips 20 degrees to the south and strikes E.W. Tuff in the vicinity of Asōnan has predominantly the same dip and strike. At Uzuranfauro on the northern slope (Ōzawa meadow) quartz andesite is exposed west of the agglomerate consisting of hypersthene andesite. White andesitic rocks observed at Parie and Pēpo areas are two-pyroxene andesite, as analyzed microscopically.

2. Mariiru limestone.

The Mariiru limestone over Hirippo and Mariiru areas is schematically developed at the railway cut at Gagane and below the cliff west of Taihanom. It is a thick deposit consisting of sandy limestone, marl, limestone, and is generally white or yellow and sometimes red or blue-black. The lower part is a conglomerate deposited unconformably over agglomerate, while the upper is conglomerate limestone, black due to its Mn content. The strike is generally N. 70° E. and dip about 15° S. At Gagane cut the formation, about 100 m. thick, strikes N. 60° W. and dips 30° S.W. It is cut by a fault. The Mariiru limestone is present at the lower and middle levels of the cliff west of Taihanom. It also occurs at the middle and upper levels of the cliff east of Hirippo and at the middle level in Mariiru area.

Fossils contained are listed below:

[See Fig. 4 and tables, 1 and 2 for the distribution of Foraminifera in the geologic column, in the formations, and in the collecting areas. Plate IV is an index to fossil and rock collecting locations].

Foraminifera:

Camerina, Pellatispira, Biplanispira, Biplanispira mirabilis (Umbgrove), Discocyclina, Discocyclina n. sp., Asterocyclina, Faviania-like form (n.gen.), Spiroclypeus vermicularis Tan Sin Hok, Acervulina n.sp., Carpenteria, Sporadotrema, Sporadotrema cylindrica (Carter), Sporadotrema?, Heterostegina, Amphistegina, Amphistegina radiata (Fichtel and Moll), Planorbulinella, Planorbulinella-type, Rotalia, Globigerina, Gypsina.

Corals:

Styrocoenia, Montastraea.

3. Taihanom limestone.

The Taihanom limestone outcrops over the Hirippo and Mariiru areas with excellent exposures along Gagane coast and at the cliff west of Haofuniya. There is a small area of Taihanom limestone at Parie. Starting from the bottom the beds are brecciated limestone, sandy limestone, calcareous sandstone, and limestone in succession.about 70 meters thick, with E-W strike and 10-15° dip south. These change to N. 30° W.

and 30^{o} S.W. respectively, along Gagane coast. The red brecciated limestones found at the northern tip of the cliff west of Haofuniya, at a limestone cave in the cliff west of Hirippo, and along the coast at Teruson cut are all lower Taihanom, while those at the cliff west of Taihanom and along Gagane coast belong to middle or upper Taihanom. The outcrop at Mariiru may be upper Taihanom. The red, brecciated limestone at Parie, containing Miogypsinoides, is also Taihanom limestone.

The stratigraphic relation between Mariiru and Taihanom limestones is as follows: at the cliff west of Haofuniya the middle level of Mariiru limestone is covered by Taihanom limestone without the Mn-bearing upper level, while along the coast at Teruson cut the agglomerate is directly covered by Taihanom limestone. These two limestones are unconformable because of different dips and strikes.

The fossils contained in the formation are as follows:

Foraminifera:

Lepidocyclina (Eulepidina) formosa
gibbosa
monstrosa
richthofeni
spp.
sp.nov.

Lepidocyclina (Nephrolepidina) Smatrensis

spp

Miogypsina

Miogypsinoides

Miogypsinoides n.sp. (aff. complanata)

Spiroclypeus

Spiroclypeus leupoldi

Spiroclypeus margaritatus

Flosculinella sp (globulus ?)

Borelis pigmeus

Heterostegina bornensis

Cycloclypeus communis

Amphistegina radiata

Sporadotrema cylindrica

Carpenteria sp.

montipora

proteitormis

Gypsina

Gypsina globulus

vesicularis

Rotalia gaimardi

schreteiniana

Acervulina inhaerens

Sorites martini

Corals:

Porites sp.

4. Hirippo limestone.

The Hirippo limestone, developed mainly in the Hirippo area, has a well-preserved exposure at the cliff west of Hirippo and frequently outcrops on the southern slope of Hirippo. [In Plate III areas shown as Hirippo are covered by thin Mariana layer. The exposure of older rocks may be slightly magnified, especially on the southern slope]. The deposit is 50 m. thick and consists of light red compact limestone, red sandy limestone, calcareous sandstone and limestone (younger to older in order). It is all reddish and exceedingly sandy. The strike is approximately N. 70° E. and dip more than 10° S. The southern and northern slopes of Rota are partly covered by a red compact limestone or red sandy limestone containing Cycloclypeus operculina. Miogypsina was found in samples of Hirippo limestone obtained by TAYAMA from Asōnan. In the northwestern area of Mariiru and along the coast of Taipinkōto there is a red limestone which is believed to be Hirippo limestone because of rock order. It contains Nephrolepidina and crab fossils.

Mariiru limestone at the cliff east of Hirippo, Taihanom limestone at the cliff west of Haofuniya, and Mariiru limestone at the cliff west of Hirippo are all overlain by Hirippo limestone.

On Poniya slope the Hirippo is in contact with white limestone which probably contains Miogypsina and Miogypsinoides that may possibly belong to Taihanom limestone. The relation between them has not been clarified yet. On the beach to the east, pebbles derived from Mariiru limestone and Taihanom limestone are found in sandy limestone. On the southern and northern slopes Hirippo limestone directly overlies agglomerate. Thus, we can assume that there is an unconformity between the Hirippo and Taihanom limestones.

The fossils contained are listed below:

Foraminifera:

Lepidocyclina (Nephrolepidina) smatrensis

spp.

(martilepidina) irregularis?

Cycloclypeus

Cycloclypeus communis

Cycloclypeus (Katacycloclypeus?)

(Katacycloclypeus) annulatus

Globigerina

Globigerina bulloides

Planorbulinella larvata

Amphistegina radiata

Acervulina inhaerens

Gypsina globulus

Orbulina universa

Pulleniatena obliqueloculata

Heterostegina

Operculina

Operculinella venosa

Corals:

Porites

Porites?

Montastraea

Favites

Favites?

Pocillopora

Pachyseris

Lamellibranchiata

Lithophaga nasuta (Phillipi)

Gastropoda

Conus sp. indet.

According to IMAIZUMI the fossil crab, Calapilia n. sp., is also present.

5. Ponia limestone.

This is a stratified limestone developed schematically over the marine cliff east of Ponia peninsula. Compared with the older limestone it is rather thin and its plane slightly irregular. The Ponia is generally gravelly, and porous containing calcareous algae such as Halimeda, shell fossils, remains of Foraminifera, and coral sand, mainly white or yellow and sometimes light red.

The limestone is found on the southern cliffs in the areas Mariiru, Parie, and particularly Hirippo. Sporadically it is found in Ganpaapa meadow. West of Shinaparu the Ponia limestone dips 15° E. and strikes N-S. Limestone similar to the above and rich in Halimeda is extensively distributed over the Shinaparu and Lugi terraces. The limestone between Sonson and Teruson is a Foraminifera limestone containing Amphistegina and Cycloclypeus. This limestone is exposed over the southern and northern cliffs on Taipinkoto peninsula with strike N. 60° E. and E-W., respectively, and both dipping about 25° to the sea. On the northern slope it cannot be clearly seen because the cliff is poorly developed, but there are good exposures at Tatacho and the cliff to the south.

The strike of this limestone is approximately parallel to the coast and dipped about 20^{o} to the sea while near Tatacho the dip is about 10^{o}. In some places Ponia limestone overlies Hirippo limestone in an angular unconformity, and in other places overlies a basal conglomerate. The Ponia overlies Taihanom limestone along Gagane coast in angular unconformity and on agglomerate along Mariiru coast and on the southern slope. In the former agglomerate gravel is not contained.

The fossils contained are listed below:

Foraminifera:

Baculogypsina sphaerulata (Parker and Jones)

Amphistegina

Amphistegina radiata (Fichtel and Moll)

Acervulina

Acervulina inhaerens schultze

Cycloclypeus

Cycloclypeus carpenteri Brady

Rotalia

Rotalia gaimardi D'Orbigny

Calcarina

Calcarina spengleri (Gmelin)

Gypsina

Gypsina globlus Reuss

Heterostegina depressa D'Orbigny

Miniacena miniacea (Pallas)

Homotrema rubrum

Marginopora vertebralis Q & G

Carpenteria

Globigerina

Operculinella cumingi

Acervulina inhaerens plana Carter

Bivalves: /Numbers in parentheses are collecting station numbers/.

(124) Vulsella ? sp.

(405) Conusmiles Linné

Callista sp.

(397) Venus toreuma Gould

(314) Conus cf. imperialis Linnaeus

(396) Turbo sp.

Turbo ?

(402) Cardium sp.

(69) Trochus sp.

In the Ponia limestone (?) near Curre along the road southwest of

Taruga following fossils are contained.

Gastropoda:

Conus cornatus Gmelin

Conus sp.

Torna perdix (Linnaeus)

Cypraea mappa Linné

Cypraea sp.

Phos senticosus (Linné)

Turbo petholatus Linnaeus ?

Turbo argyrostemus

Turbo sp.

Trochus cf. niloticus

Lamellibranchiata:

Plicatula sp.

Arca reticulata Gmelin

Arca arabica phillipi

Rocellaria gaudix (Deshoges)

Venus reticulata

Venus toreuma Gould

Venus marica Linné

Ostrea

Cardium

Glycymeris sp.

Lima sp.

Pecten sp.

Echinoidea:

Clypeaster sp. indet.

6. Mariana limestone.

This limestone, which is white, light yellow, or light brown covers the greater part of the island. The Mariana is generally porous, massive, and unstratified and was apparently horizontally deposited. It is mainly formed of coral limestone derived from various well preserved reef-building corals and is typically developed on Sabana Terrace. In places it consists of _Halimeda_ limestone. Near the contact with agglomerate it is sandy and reddish colored with conglomerate at the base. The conglomerate bed below the Mariana limestone cliff at Gagane cut and along Mariiru coast may be a basal conglomerate.

We shall next examine its stratigraphic relationship with Ponia limestone. The contact between Ponia limestone and basal Mariana limestone (conglomeritic in character) on the surface of the cliff along Parie coast is not sharp. Ponia limestone gradually changes into nonstratified Mariana limestone at the higher level. This may be an angular

unconformity. North of Haofuniya there is a nonstratified yellow limestone overlain by white limestone containing andesite gravel near its base. The contact is horizontal and may be Ponia limestone below and Mariana limestone above. The contact north of Haofuniya (180 meters high) and along the Parie coast is regarded as an unconformity. There is an angular unconformity between stratified Ponia limestone and overlying non-stratified and horizontal Mariana limestone. But in this case there is a transition zone with no definite boundary between the two formations.

Along the east coast and at Aragan is a horizontally stratified limestone which is not identifiable from a distance, but may be Mariana limestone due to the absence of dip.

Next we shall consider the relation between the coral lime stone of the highest terrace, the Sabana (470 meters high), and the Ponia limestone at the bluff less than 200 meters high. From an exposure of the agglomerate at Sabana terrace some leveling of the ground below the limestone may have been taking place before corals were deposited. Boring in the south western area about the middle of the terrace shows the limestone attains a thickness of about 20 meters while at the southern cliff it is 100 meters thick above the agglomerate. What conditions prevailed around the present island such that corals could

not develop? The inclination of the ground rock connected by outcrops of the agglomerate in the cross-section of the present topography is less than 15° at the steepest northern slope and only about 10° at the southern. Were it not for the powerful action of sea currents, clastic material from the beach would be expected. Such deposits, however, are not found over Ponia limestone. Moreover, this deposit should be equivalent to Ponia limestone in rock character.

In the middle of Taipinkoto peninsula Mariana limestone is 140 meters high and is regarded as an elevated table reef. Ponia limestone below the northern and southern cliffs of this Mariana limestone is only 400 meters apart, but the opposite inclinations to the sea amount to 30° on both sides. The stratigraphic relation between the Ponia and Mariana limestones is not clear. The deposits steeply inclined in opposite directions with such a short distance between makes it difficult to regard Ponia limestone as sedimentary matter prior to the deposition of corals.

From the above consideration, these limestones may be contemporary and the unconformity between the two limestones at Parie and Haofuniya may be explained as follows: The unconformity between Mariana limestone deposited over Ponia limestone during the formation of Sabana terrace shows the difference in formation of Mariana limestone at

Sabana terrace and upper limestone. Furthermore, the interval between the two limestones seen at the various cliffs, which was regarded as an angular unconformity, may not have been so long a time, though they were not contemporary. As Mariana limestone can be divided into upper and lower by the formation period of terraces, so Ponia limestone can also be divided. On the outer inclined surface of the present coral reefs some beds corresponding to Ponia limestone may be developed.

Naftan limestone (Saipan) corresponding to Ponia limestone is observed at a level lower than Mariana limestone and the exposure is also lower than Mariana limestone on Saipan where older limestones are found higher than Mariana limestone (Carolinas limestone higher than Mariana limestone in Tinian island is not clearly defined by TAYAMA). These two Foraminifera-bearing limestones have many points in common. The existence of Foraminifera (mainly <u>Cycloclypeus</u>) in Ponia limestone which is not found along the coast shows these two limestones were formed in the same epoch (?).

The fossils contained are listed below:

Foraminifera:

Cycloclypeus

Heterostegina

Amphistegina

Acerbulina

Planorbulinella

Rotalia

Globigerina

Gypsina

Sclites

Homotrema rubrum (Lamarck)

Marginopora

Operculina

Spiroloculina canaliculata D'orbigny

Triloculina trigonula (Lam)

Corals:

Porites sp.

Montastraea cf. curta (Dana)

Favia stelligera (Dana)

Favia cf. stelligera

Galaxea fascicularis (L)

Acropora sp.

Asteropora

Cyphastrea chalcidicum (F)

Leptoria phygia (Ell et Sol)

Leptastraea cf. purpurea (Dana)

Platygyra cf. ryukyuensis K & S

Fungia sp.

Pocillopora sp.

Symphyllia cf. recta (Dana)

Acanthastraea sp.

Bivalves:

Tridacna squamosa Lamarck

Cardita variegata Haaley

Pecten sp.

L. 4. Tridacna:

Anodontia pila (Reeve)

Tellina discus

Gafrarium pectinatum (Linné)

7. Rota limestone.

Rota limestone outcrops in a narrow band encircling the island as high as 20 meters and at about 30 meters in the southwest. It is generally coralline limestone and in some places contains numerous Foraminifera. Halimeda is found in large quantity near Sonson. The limestone resembles Mariana limestone in lithology and fossils

contained and can be distinguished only by topographic features.

The contained fossils are listed below.

Foraminifera:

Cycloclypeus

Heterostegina

Amphistegina

Amphistegina radiata (F & M)

Acervulina

Rotalia

Gypsina

Calcarina

Marginopora

Operculina

Shark teeth are found along the coast south of Taipinkoto.

Bivalves:

Asaphir dichotoma (anten)

8. Raised beach deposits.

This formation constitutes the northern coast of the island, and is especially well-developed near Sonson. The formation consists mainly of sand from coral reefs and Foraminifera; the remains of Echinoderms and Mollusks are also found. The Foraminifera are mainly

Calcarina and some calcareous algae, Halimeda and Corallina. Near the city of Sonson it is conglomeritic, mainly of coral masses. The formation is distributed along the coasts of Gagane and Aueniya in small patches.

The Raised Beach Deposits are in part contemporaneous with Rota limestone and in part overlies it. Near Sonson it is higher along the coast and lower farther inland. Southwest of the plant this stratified formation containing many Halimeda covers the notch of Rota limestone and appears to dip northward.

The contained fossils are listed below:

Foraminifera:

Gypsina

Calcarina

Calcarina spengleri (gmelin)

Miniacena miniacea (Pallas)

Marginopora

Marginopora vertebralis Q & G

9. Mirikattan limestone.

This is a recent raised coral limestone rising 1 - 3 meters above the water surface. In several localities around the island, especially at Mirikattan harbor and along the coast south of Sonson it is well

developed. The state of coral growth is well preserved. At Mirikattan and along the southern coast of Taipinkoto the base of the formation consists of weathered conglomerate, fossil shells, and sea urchin spines. The rock itself resembles Mariana and Rota limestones. Due to red spotting, it resembles present coral reefs.

The boundary with other limestones is difficult to determine. The contact with the raised beach deposits is also difficult to determine because of the sand cover. Judging from an exposure it appears that the raised beach deposit is covered by Mirikattan deposit which is in turn overlain by aeolian sand. It is believed that during the formation of Mirikattan limestone, eroded particles were transported to the shore and deposited there. The latter idea is assumed from the fact that Foraminifera sands are deposited in the inner part of the present reef where raised beach deposit beds are never developed.

The fossils contained are listed below:

Corals:

Porites sp.

Montastraea vesipora (Lam)

Montastraea ? sp.

Favia speciosa (Dana)

Favites cf. abdita (Ell & Sol)

Seriatopora damicormis

bulbosa Ehr.

Galaxea cf. musicalis (L)

Acropora sp.

Montipora sp.

Goniastraea retiformis (Lam)

Asteropora

Heliopora caerulea (Pallas)

Bivalves:

Lamellibranchiata

Septifer bilocularis Linnaeus

Arca

Tridacna squamosa Lamarck

Gastropoda:

Conus sp.

Trochus

Turbo petholatus Linnaeus

Turbo

Cypraea

10. Recent limestone.

This limestone is well developed along the beach line where a

sandy beach is usually present. It is submerged at high tide and exposed at low tide. The Recent is a sandy limestone containing many Foraminifera; it is not well cemented. The formation dips about 10° toward the sea and is extensively developed near the harbor. The coral limestone at the same level is also part of this limestone. Foraminifera contained are listed below:

Cycloclypeus

Amphistegina

Gypsina

Calcarina

Marginopora

M. vertebralis Quoy & Gaimard

This limestone will gradually be tranformed into the present coral reef surface.

C. Correlation of Rota Strata with other Pacific Island Formations.

Manila agglomerate, the basement rock of the island, may be correlated with Hagman andesite in Saipan which is underlain by lava (see Fig. 5). It is difficult to determine what underlies the agglomerate on Rota. Moreover on Saipan the agglomerate is intruded by quartz-andesite and this may be seen also on [Rota] island. Mariiru limestone, corresponding to Matansya beds on Saipan, is late Eocene judging from fossils contained.

In Saipan the lower and middle [Matansya] contain both large andesite conglomerate and tuff deposits. On the other hand, those on Rota island are all calcareous and exceedingly thick compared with the upper [Matansya] limestone mentioned above. This upper manganese-bearing limestone closely resembles the manganese-bearing Hagman limestone.

Taihanom limestone belonging to the Aquitanian "e", viz., late Oligocene period, judging from its fossils corresponds to Laulau limestone on Saipan. On Saipan the formation lies between Densinyama and Donny beds of the Oligocene period which are absent on Rota. Sandy limestone and marl resembling the Donny beds cover the upper and middle surfaces. Kasutesho limestone and Tinian beds are contemporary on Tinian.

The lower and middle of Hirippo limestone is of Burdigarian "f" period and is determined as lower Miocene from fossils. Index fossils were not found in upper Hirippo. The Hirippo limestone is exceedingly sandy and red compared with contemporary Tappocho (on Saipan) and Lasso (on Tinian) limestones. Ponia limestone, corresponding to the Carolinas limestone on Tinian and Naftan limestone on Saipan, closely resembles them in lithology and fossils contained, but no index fossil was found to establish the period.

The Mariana limestone, extensively distributed in the southern Marianas, may be correlated to the Mariana limestones in Saipan and

Tinian, Palau limestone developed over Palau islands, and Garim limestone on the Yap islands. It may be Plio-Pleistocene.

Rota limestone is correlated to a raised coral reef limestone on Saipan and Tinian, and Peleliu limestone developed on Palau islands, Mirikattan limestone corresponds to the younger part of these elevated coral reef limestones. At Rota island these two limestones are clearly separate units.

Recent limestone may be correlated to the corresponding limestones on Saipan and Tinian.

The formations below Mariana limestone on Tinian and Saipan are covered by a reddish-brown clay bed (see Fig. 5). On the other hand, Rota island is almost covered by an exposure of reddish-brown limestone which is very thin except in Lugi zone.

D. Faulting.

Fault lines were observed only in the Hirippo and Parie areas [see Plate III]:

1. Gagane fault.

Gagane fault is exposed at the railway cut at Gagane, the fault surface striking N. 20° E. and dipping 75° E. The western side is agglomerate and the eastern is Mariiru limestone, the down-dropped side. The southward extension may cut the boundary between Mariiru and Taihanom

limestones, and the northern extension is definitely covered by Mariana limestone. The fault may be formed between the deposits of Taihanom and Mariana limestones.

A fault plane NS in strike and dipping 50° E. is observed cutting Taihanom limestone along Gagane coast. On examination of the formation it is a thrust fault. The northern extension is likely a connection of agglomerate and the limestone south of Gagane.

2. Hirippo fault.

In Hirippo area a fault cuts Hirippo limestone with its plane striking N. 40° E. and dipping 50° E. The limestone stands vertically on this account. Judging by the dip and strike the many slip faults in calcareous sandstone contained in Taihanom limestone near Ponia promontory are extensions of the Hirippo fault.

On the cliff west of Hirippo, north of this fault-line Taihanom limestone is observed to the north, and agglomerate and Mariiru to the south with no Taihanom limestone exposure. The distribution of Ponia limestone along Gagane coast may have been influenced by this fault. Moreover, Hirippo limestone cave was probably formed by water action along this fault line. The fault line does not extend northward to Mariana limestone. The faulting took place before the deposition of Mariana limestone and after that of Ponia limestone but there is evidence

of faulting before the deposition of Hirippo limestone.

3. Fault north of Haofuniya.

North of Haofuniya, viz., about 50 meters east of the northern end of the cliff west of Haofuniya there is observed a minor fault with dip and strike 50° E. and N-S, respectively. The western part is composed of white limestone regarded as the upper middle Mariiru limestone while the eastern is yellow limestone regarded as Ponia limestone. Along the fault plane the formation is sandy or clayish and contains white angular limestone gravel of Mariiru limestone. The extension of the fault is difficult to trace because of the cover of Mariana limestone. Judging from the presence of Mariana limestone on Ponia limestone east of the fault, the faulting may have taken place after a part of Mariana limestone was formed.

4. Parie fault. [Location of fault on geologic map is not clear].

East of Parie office a thrust fault is observed deeply cutting Ponia limestone beneath agglomerate whose contact plane is N-S and 50° westward [?].

5. Lugi fault-line.

This line runs from Tenazēsan to Moore passing through the boundary between Lugi and Shinaparu terraces. Along this line there extends a low area with deep soil.

6. Iisan fault-line.

This line runs west of Sabana terrace. The southward depression at Iisan upper level and the gentle inclination of Ponia limestone south of Tatacho all show a southward depression of the western block along this line. No exposure of agglomerate is seen on the western side.

7. Mariiru fault-line.

Along the Mariiru coast an exposure of Taihanom, Ponia, and Mariana limestones is seen as shown in Fig. 6. (Because of the cliff, field investigation was impossible). When a thrust is considered, the condition may be as shown in Fig. 6b and otherwise it may be as shown in 6c.

In the latter case Ponia limestone P_1 and Mariana limestone are not always contemporary. Mariana limestone M_1 at a higher level is contemporary with Ponia limestone P_1 deposited at the foot of the cliff of Taihanom limestone, and then Mariana limestone was formed after the cliff elevated.

E. The Andesite of the Manila Agglomerate (Part 1). (This section is based upon YOSHII's description).

Hornblende-augite andesite.

This rock contains not only augite but also hypersthene and small

quantities of hornblende. The groundmass is brown and of hyalopilitic texture.

Hypersthene-augite andesite.

This rock is slightly porphyritic and sometimes porous. The small phenocrysts consist of feldspar and augite while the hyalopilitic ground mass is composed of a brown glassy material, a number of fine crystals of feldspar and hyperthene, and a small number of magnetic grains.

Feldspar phenocrysts containing basic Labradorite are mainly idiomorphic, usually less than 1 m.m. long although some exceed 2 m.m. Commonly, combined Albite and Carlsbad twinning and conspicuous zoning are present, and it is optically negative.

The Hypersthene is also mostly idiomorphic. Augite prisms are 1 to 2 m.m. long, but the fragments are small. It is light green, has a large extinction angle $Z \wedge C = 51^{\circ}$, and occasionally is twinned. Hypersthene prisms are about 0.8 m.m. long and have a pronounced pleochroism. Sometimes a tiny crystal of hypersthene is observed in the augite contained in the ground mass.

Andesite tuff.

This is related to the two-pyroxene andesite.

(Part 2)

I. Two-pyroxene andesite (Augite-hypersthene andesite) at Gagane cut No. 6 (4).

Macroscopic observation.

Color: dark gray.

Minerals: Feldspar - Predominant and 1 to 3 m.m. long.

Pyroxene - Usually 1 to 2 m.m. long, sometimes 5 m.m., next to feldspar in abundance.

Others - Reddish-brown phenocrysts, about 1 m.m. long, and wedge-shaped. Olivine is not determinable.

Texture: Phanerocrystalline, porphyritic, rather compact and solid, but vesicular cavity 0.5 m.m. in diameter is observed; the ground mass is aphanitic.

Microscopic observation.

Structure: hyalopilitic (dopatic and sempatic).

Phenocrysts: Plagioclase - the most abundant mineral, commonly about 1.5 m.m. but attains a length of 2.5 m.m., it is idiomorphic, prismatic with zoning and twinning slightly developed, rich in inclusions, frequently arranged zonally, mainly pyroxene.

Hypersthene - commonly 2 m.m. long and maximum up to 3.5 m.m., next to plagioclase in abundance, idio-hypidiomorphic, long prisms, yellowish-brown or light bluish-green, strong pleochroism. Growth is frequently parallel to augite, straight extinction.

Augite - 1 m.m. long, generally smaller and less abundant than hypersthene. Prisms are short, colorless, nonpleochroic, generally twinned, higher in birefringence, and fresher than hypersthene.

Olivine (?) - Some pieces are olivine-like in character.

Texture.

Structure: Generally hyalopilitic or intersertal, slightly fluidal, with radially developed calcite in cavities. Calcite is also developed along the fissures in the ground mass and spaces in feldspar.

Minerals: Plagioclase.

Pyroxene.

Magnetite - sparsely distributed in small grains.

II. Hypersthene-augite andesite. (at 117 on the northern slope).

Microscopic observation.

Structure: Hypocrystalline porphyritic, perpatic or dopatic, hyalopilitic or pilotaxitic.

Phenocrysts: Plagioclase - usually 0.5 m.m. and up to 1.5 m.m. long, occupies a greater volume than the other minerals but is less in number, is idiomorphic with slightly developed zoning and twinning.

Augite - generally 0.5 m.m. long, idiomorphic or hypidiomorphic, colorless or pale green.

Hypersthene - far less abundant than augite, 0.8 m.m. long, frequently found in an aggregate with idio- or hypidiomorphic magnetite, and pleochroism strong.

Magnetite - 0.25 m.m. long, idiomorphic or irregular polymorphic.

Texture: Hyalopilitic or pilotaxitic.

Structure: Hyalline and very strong fluidal structure.

Minerals: Plagioclase - usually 0.5 m.m. long, sometimes with relatively larger feldspars.

Pyroxene.

Magnetite - in specks.

III. <u>Others</u>.

Gagane cut

No. 6(3) Two-pyroxene (hypersthene-augite) Andesite

Minerals: plagioclase - - - zonal inclusion.

pyroxene - - - - parallel growth.

augite - - - - - zonal structure.

Structure: andesitic texture (hyalopilitic).

dopatic or sempatic.

percrystalline.

Macroscopic examination: mediophyric.

phanerocrystalline porphyritic.

No. 6(1) same as above.

No. 6(2) augite-andesite.

Taihanom - two-pyroxene andesite.

Northern slope, no. 112 - propirite.

Mt. Manila, no. 192 - two-pyroxene andesite tuff (agglo).

Northern slope, no. 117 - hypersthene hyalo dacite (glassy)

Dacite was obtained at Gagane cut.

(IV) NATURE OF THE TERRACES

How have the terraces of Mariana limestone been formed which are developed stepwise from the top of the mountain to the coast?

The terraces on Saipan are considered abrasion terraces by TADA while TAYAMA regards them as deposition terraces. TAYAMA's view is supported by ONOYAMA whose theory cited here reveals the character of the terrace on the island.

"If all the limestones constituting each terrace were formed in the same process without any time discontinuity, the terrace may be determined to be due to sea erosion. If there were any time interval between formations it would be explained as remnants of reef plains or it would be necessary to consider a complicated movement of elevation and subsidence according to the arrangement of formations. As the historical relations are not determined, we have no other means than to draw conclusions from the distribution of elevated coral reefs, relation with ground formation, or combination of topographical elements. In the stratigraphic relation between raised limestone and present coral reef a distinct boundary is difficult to draw. The former is decidedly of elevated character and the latter is distinctly a present formation, and accordingly the boundary should exist. Suppose these two limestones were elevated; a continuous sheet of limestone would be expected because of the similar character of these rocks and the poorly defined boundary. Here exists a danger of mistaking the reef surface for an abrasion surface.

"When a coral reef coexists with other rocks, different rocks

may be cut by the same terrace. While the terrace is being formed in one area, other reefs may be increasing the area where the coral reef is developing. Because of this the erosion surface and reef surface may be different in height or at the same level. When leveling progresses on the erosion surface with the development of an abrasion surface, the abrasion surface and coral surface may be at the same level in the same area".

It would be hard to classify the terraces into younger and older by each terrace level and the erosion condition at the cliff face between them. By comparing corals at each level it is expected that the higher the level the worse the preservation.

From the above considerations each terrace may be considered due to the formation of a raised reef surface during the cessation period between intermittent elevations. Accordingly the number of terraces corresponds to that of elevations. Its extent will depend upon the length of cessation and the inclination of the ground.

The fact that the uppermost terrace, Sabana, resembles the present barrier reef and the top of Mt. Manila consists of limestone indicates that the table reef formed at the top of the island when the present island was submerged formed a fringing reef around the island and then a raised barrier reef was formed. The terraces below the second are

the successive elevated fringing reefs developed around Sabana terrace. The terraces up to Shinaparu and Lugi constitute the central plateau of the island while the others are developed around them.

From an exposure of agglomerate near Sabana office and above and northwest of the spring, based upon an account by KANEMATSU, the ground surface below the limestone of Sabana terrace may have been more or less leveled before the deposition of corals.

All the terraces formed of limestones lower than Mariana limestone are regarded as erosion terraces cut by the Mariana sea.

In the distribution of terraces there is no marked difference on the southern and northern sides but the terrace cliffs on the northern slope are more distinct than on the southern. A striking asymmetry on the eastern and western slopes is observed. On the latter slope the terrace is narrow but the cliffs are distinct and high; the terraces of the former are wide but the cliffs are indistinct and low. Generally high cliffs in the north-west and low cliffs in the south-east is the pattern. The lower terraces such as Teruson, Sonson, and Mirikattan correspond to the deposition surfaces of Rota limestone, Raised beach deposits and Mirikattan limestone, respectively. The western part is more developed in these areas, too.

(V) CORAL REEF DEVELOPMENT

A remarkable difference in coral reef development is seen along the south-east and north-west coasts.

Undeveloped coral reefs (fringing reefs) are usually seen along the south-east coast, mostly about 20 meters wide and sometimes are taken for abrasion terraces below the limestone cliff. The outer fringe of barrier reefs is approximately linear. Beach sand or present limestone is observed along the inner surface of the fringing reef where agglomerate is exposed. Along Aueniya coast the reef surface has two levels; only the higher inner level is visible at high tide.

Compared with the south-east coast, the coral reefs along the north-west coast are developed up to a width of 100 meters and the inner zone of the reef surface is covered by the coral and Foraminiferal sands. Along Sonson coast the coral plain is divided into two levels, as along Aueniya coast, and both surfaces are tilted toward the island showing recent tilting.

A pseudo-fringing reef is developed at Sanrago mooring place (near Sonson) along the western coast. Coral reef in a sand spit projects northeastward from below the cliff west of Taipinkoto and southwestward from north of Mirikattan. The former is 2 kilometers

long and the latter 1 kilometer. The width of the coral plain averages 50 meters. Within the coral plain of the former Mirikattan limestone is less than 2.5 meters high. Enclosed by these two reefs is a reef lagoon about 3 kilometers long, 100 to 200 meters wide, and about 5 meters deep. The eastern corner of the lagoon is dotted with a small island of coral limestone about 2 meters high (Rota Matsushima). Along the inner fringes of the lagoon beach sand and present limestone are observed. Where beach sand is absent there is coral limestone (Acropora and other genera). The channel lies at Mirikattan through which fishing boats pass. Ships enter also through another channel at Anzota island west of the above.

In the bay of Sosanjaya there is a kind of pseudo-barrier reef.

(VI) TECTONIC MOVEMENT

TAYAMA's report on the tectonic movements of marine ridges and the archipelago west of the South Sea Islands was studied. A reference is made here about the paragraph on the Mariana ridge, viz., southern Mariana islands of which Rota island is a member.

"Land terrain is steep on the west and gentle on the east while the marine portion is the reverse. The higher terraces are extensively developed on the eastern side and the lower terraces on the western.

"In the tectonic movement of the ground mass we assume first a symmetrical marine ridge on both sides, eastern and western. Then we assume a ground movement occurred with a small inclination in the west and large in the east. Lastly suppose the western inclined surface was down-dropped along a fault. An asymmetrical section mentioned above would be obtained.

"A remarkable asymmetry of coral reefs on both sides is seen, for most barrier reefs are developed on the west while there are merely apron reefs and fringing reefs to the east. This asymmetry may have been developed by the recent tectonic movement with smaller inclination on the west and greater dip on the east".

Since Rota island is oblique to the direction of the archipelago, the comparison above between east and west is no other than that of southeastern and northwestern sides.

(VII) CONCLUSION [Historical Geology of Rota]

The foundation of the island was formed by the deposition of agglomerate during volcanic activity in the Tertiary along Mariana arc. The ground formation of all raised coral reefs on Saipan and Tinian islands in the southern Marianas was supposed to be formed in this period.

Erosion and faulting of the subsequent deposits of Mariiru,

Taihanom and Hirippo limestones produced the present ground form by the end of the Tertiary. Tertiary formations, which are all sandy and contain calcareous Foraminifera and very few corals, show no evidence of bygone coral reefs.

The table reef, formed by corals at the top of Mt. Manila during the temporary submergence late in the Tertiary or early Quaternary, formed a fringing reef during emergence and then barrier reef after submergence. Evidence of this will be seen on Sabana terrace.

Since that time elevation of land has occurred intermittently with a series of elevation and slight subsidence. The existence of reef terraces clearly shows that the sea during each period eroded the older rocks and deposited limestone at the extremities.

While Mirikattan limestone was being formed, the land subsided about 10 meters and a pseudo-barrier reef was formed near Sonson.

The two levels of the present coral reefs indicates that the upheaval motion is now going on.

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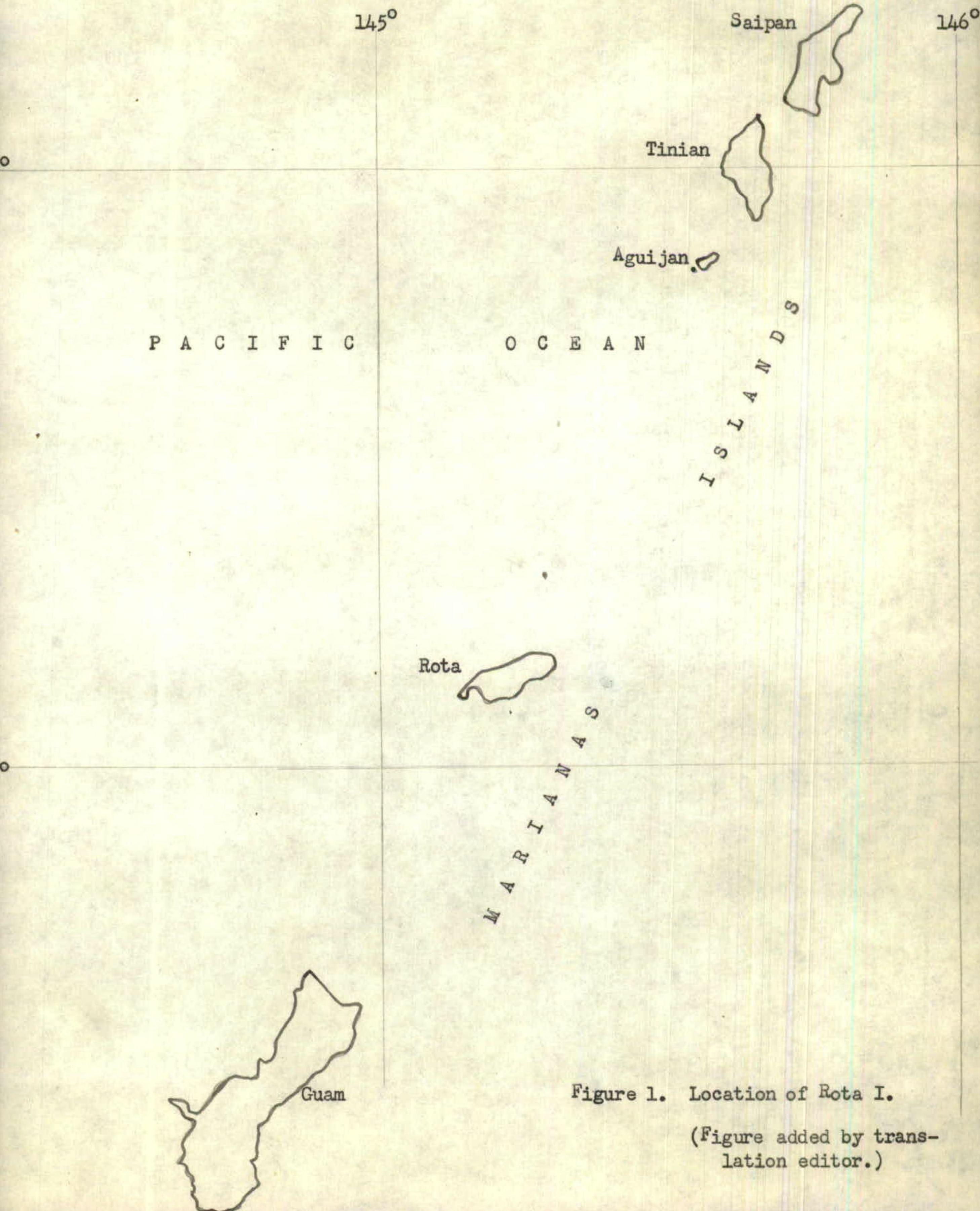
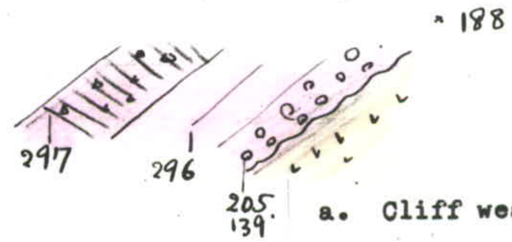


Figure 1. Location of Rota I.

(Figure added by translation editor.)

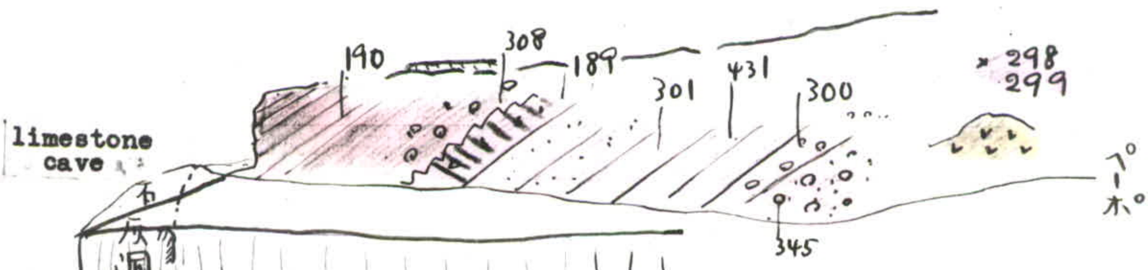
Figure 2. [Sketch of the Stratigraphy of Cliffs and Road Cuts in the Hirippo Area, Rota Island.]

ペーポ西崖.



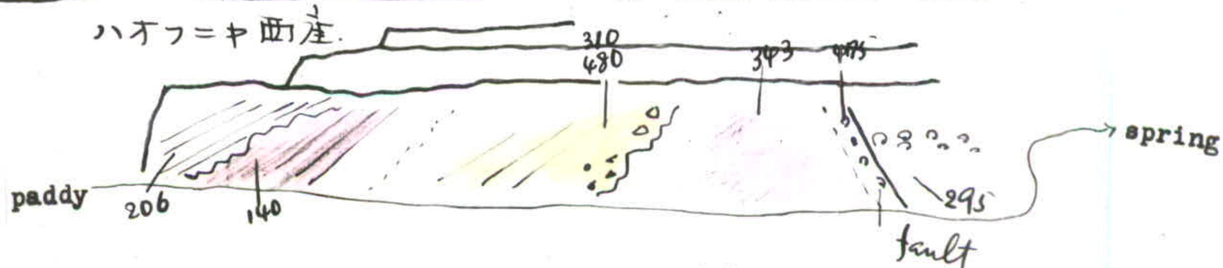
a. Cliff west of Pēpo

ヒーリッポ東崖.



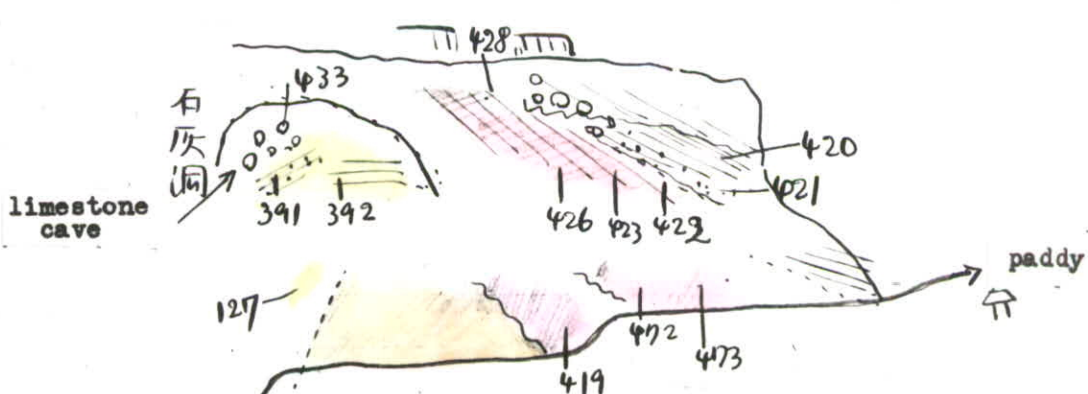
b. Cliff east of Hirippo

ハオフニヤ西崖.



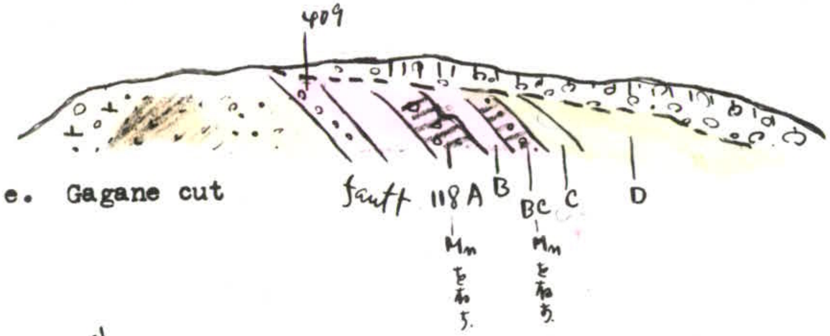
ヒーリッポ西崖.

c. Cliff west of Haofuniya



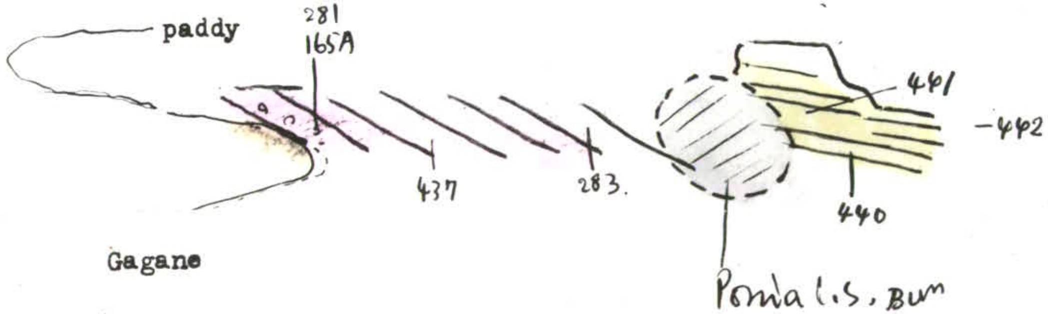
d. Cliff west of Hirippo

ガガネ切割



e. Gagane cut

タイハノム崖



f. Taihanom cliff

Mariana l.s.

Figure 3. A Stratigraphic Correlation of Formations on Rota Island by Areas.

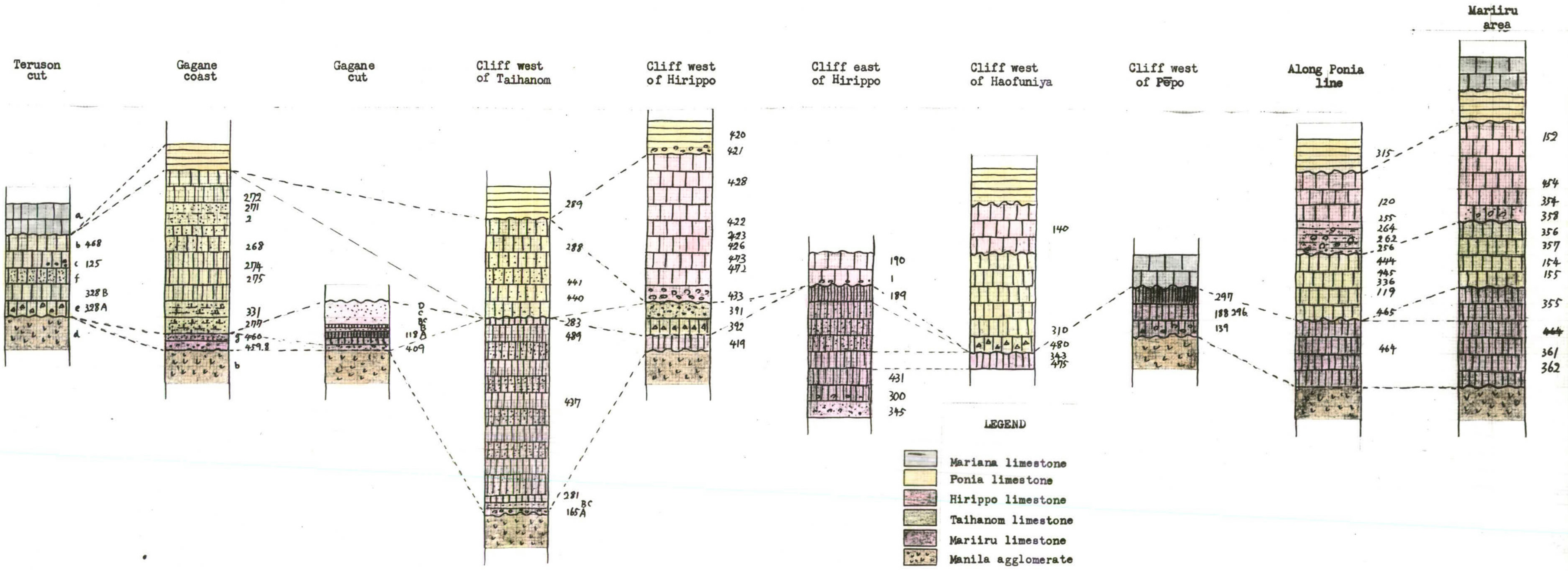
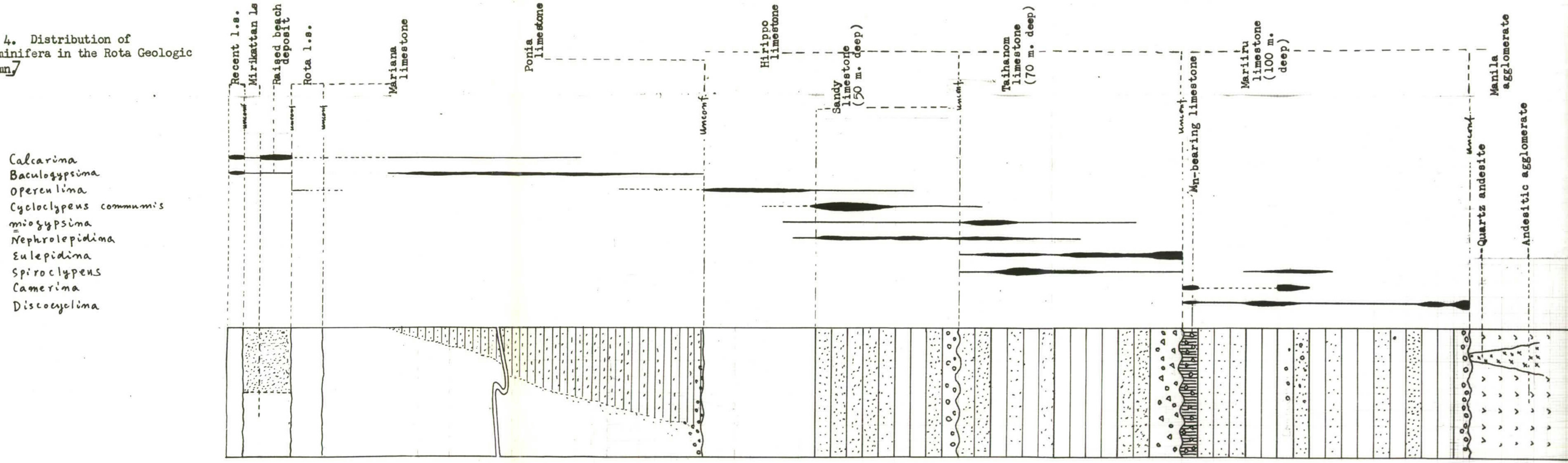


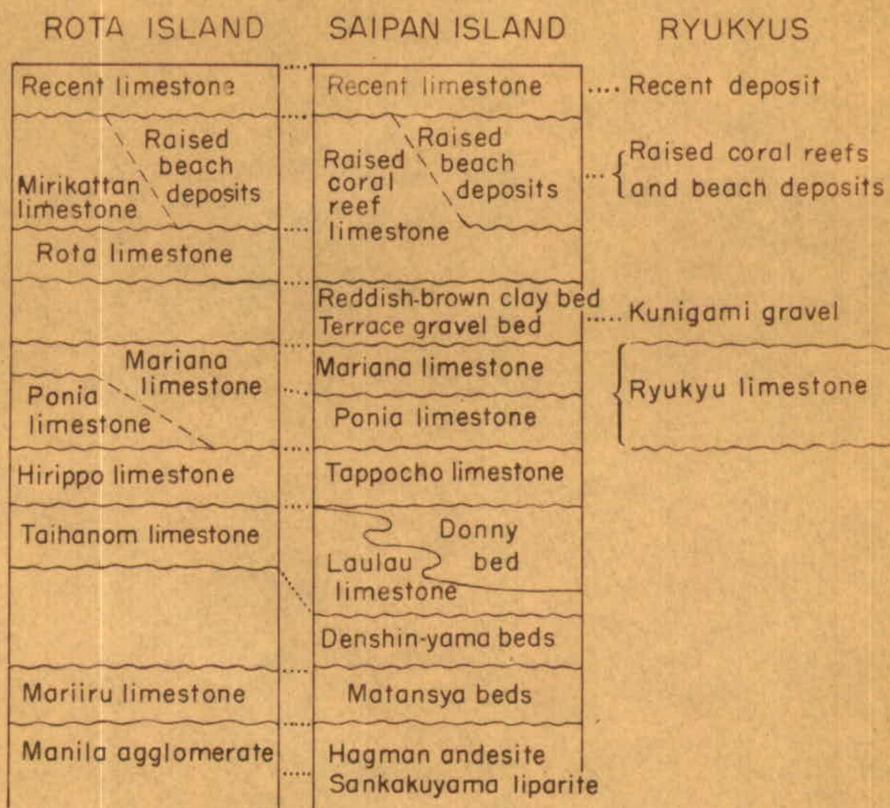
Figure 4. Distribution of Foraminifera in the Rota Geologic Column



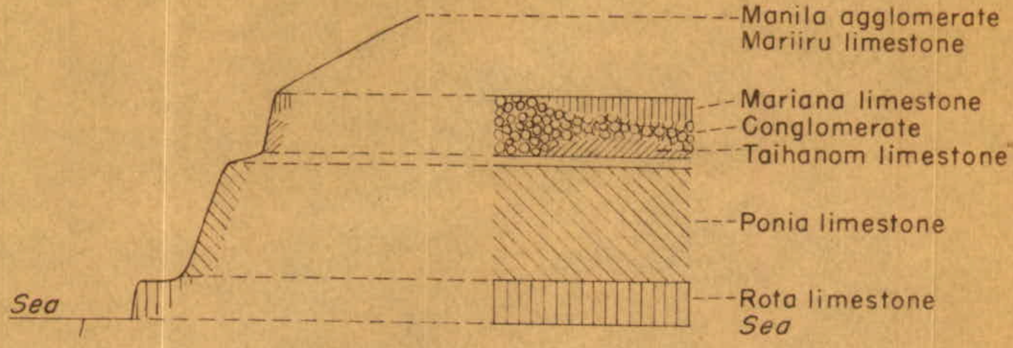
[TABLE 1. DISTRIBUTION OF FORAMINIFERA IN THE FORMATIONS]

	Mariru Limestone	Talhanom Limestone	Hirippo Limestone		Ponia Limestone	Mariana Limestone	Rota Limestone	Raised Beach Dep.	Mirikittan L.S.	Recent Limestone
Camerina	×									
Camerina ?			(×)							
Pellatispira	×									
Pellatispira ?	×									
Biplanispira mirabilis (Umbgrove)	×									
Biplanispira	×									
Biplanispira ?	×									
Discocyclina	×				(×)					
Asterocyclina	×									
Fabiania-like form n.gen.	×									
Polylepidina	×									
Spiroclypeus vermicularis Tan Sin Hok	×									
Spiroclypeus leupoldi V. d' Vlerk		×								
Spiroclypeus margaritatus Schlumberger		×								
Spiroclypeus		×								
Spiroclypeus ?		×								
Lepidocyclina (Eulepidina) formosa (Schlumberger)		×								
Lepidocyclina (Eulepidina) formosa (Schlumberger) ?		×								
Lepidocyclina (Eulepidina) gibbosa (Yabe)		×								
Lepidocyclina (Eulepidina) globosa (Yabe)		×								
Lepidocyclina (Eulepidina) monstrosa (Yabe)		×								
Lepidocyclina (Eulepidina) richthofeni (Smith)		×								
Lepidocyclina (Eulepidina) n.sp		×								
Lepidocyclina (Eulepidina)		×								
Lepidocyclina (Nephrolepidina) smatrensis (Brady)		×	×							
Lepidocyclina (Nephrolepidina) smatrensis (Brady) ?		×								
Lepidocyclina (Nephrolepidina) angulosa Pravali ?			×							
Lepidocyclina (Nephrolepidina)		×	×							
Lepidocyclina (Nephrolepidina) ?			×							
Lepidocyclina (Multilepidina) irregularis Hanzawa ?			×							
Lepidocyclina (Amphilepidina)			×							
Miogypsinoides n.sp. (aff. complanata) ?		×	×							
Miogypsinoides		×								
Miogypsina		×	×							
Flosculinella (globulus type) n.sp		×								
Cycloclypeus communis Martin			×							
Cycloclypeus (Katacycloclypeus) annulatus			×							
Cycloclypeus (Katacycloclypeus ?)			×							
Cycloclypeus carpenteri Brady				×	×					
Cycloclypeus carpenteri Brady ?				×						
Cycloclypeus gümbelianus					×					
Cycloclypeus		×	×	×	×	×	×			×
Carpenteria montipora		×								
Carpenteria proteiformis Göes		×								
Carpenteria proteiformis Göes ?		×								
Carpenteria	×	×								
Sporadotrema cylindrica Carter	×	×								
Sporadotrema	×									
Heterostegina bornensis V. d. Vlerk		×								
Heterostegina bornensis V. d. Vlerk ?		×		*						
Heterostegina depressa d'Orbigny				×	×					
Heterostegina										
Amphistegina radiata (Fichtel & Moll)	×	×	×	×	×					
Amphistegina	×	×	×	×	×	×	×			×
Acervulina inhaerens Schultze		×	×		×					
Acervulina inhaerens Schultze v. plana Carter		×	×	×	×					
Acervulina n.sp.	×									
Acervulina					×	×				
Planorbulinella larvata (Parker & Jones)			×	×						
Planorbulinella	×	×		×		×				
Rotalia gaimardi d'Orbigny		×			×					
Rotalia schroeteriana Parker & Jones		×								
Rotalia	×	×	×	×	×		×			
Globigerina bulloides d'Orbigny			×							
Globigerina	×		×	×	×	×				
Gypsina globulus Reuss		×	×		×					
Gypsina vesicularis (Parker & Jones)										
Gypsina vesicularis (Parker & Jones) var. discus Göe	×	×								
Gypsina inhaerens Schultze							×			
Gypsina			×	×	×	×	×	×		×
Borelis pigmeus Hanzawa		×								
Sorites martini ?		×								
Sorites ?						×				
Orbulina universa d'Orbigny			×							
Orbulina				×						
Pulleniatina obliquiloculata (Parker & Jones)			×							
Baculogypsina sphaerulata (Parker & Jones)					×					×
Calcarina spengleri (Gmelin)					×			×		
Calcarina							×	×		×
Miniacina miniacea (Pallas)					×			×		×
Homotrema rubrum (Lamarck)			×							
Marginopora vertebralis Quoy & Gaimard					×			×		×
Marginopora					×	×	×			
Operculina			×	×		×	×			
Operculinella venosa Fichtel & Moll.				×	×					
Operculinella cumingii					×					
Operculinella				×						
Spiroloculina canaliculata d'Orbigny						×				
Textralia					×	×				
Triloculina trigonula (Lamarck)						×				
Discocyclina n.sp	×									
Planorbulinella type n. gen.	*									

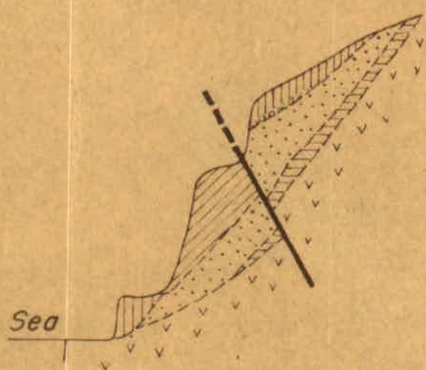
[Figure 5. Correlation chart of the strata of Rota, Saipan and the Ryukyus]



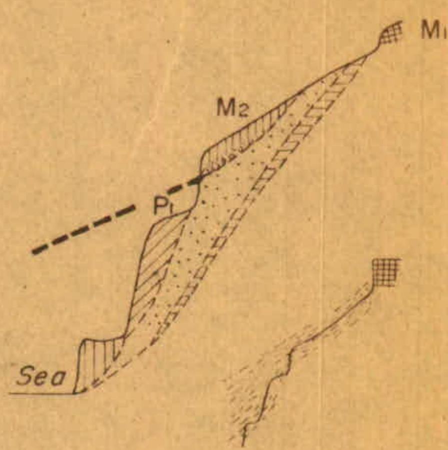
[Figure 6. Sketches of vertical-sections at the Mariiru exposure]



[a. Sketch of the stratigraphic sequence exposed at Mariiru.]



[b. Cross-section of 6a. if interpreted as a thrust fault.]



[c. Cross-section of 6a. if the Ponia and Mariana limestones were contemporaneous for a time.]

OKINAWA FORESTS

PREPARED BY
U. S. GEOLOGICAL SURVEY
MILITARY GEOLOGY SECTION

Pacific Geological Surveys.
Geological Survey Branch
Intelligence Division

~~UNDER DIRECTION OF~~
OFFICE OF THE ENGINEER
GENERAL HEADQUARTERS, FAR EAST COMMAND

December 1948

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OKINAWA FORESTS

FOREWORD

This report was prepared by Roy W. Simonson, Clarence S. Coleman, and Edward H. Templin, soils scientists assigned to the Military geology Section of the United States Geological Survey, from data gathered in connection with the detailed geological and soils surveys of Okinawa under the direction of the Engineer, General Headquarters, Far East Command. Since final reports and maps will not be published for some time, this brief treatment of the Okinawa forest problems was prepared for immediate use in response to requests from officials of the Ryukyus Military Government Team.

INTRODUCTION

Forests are of special importance to the people on Okinawa. Wood is the principal fuel, and it is also the primary construction material for buildings. Fuels other than wood are utilized to a very limited degree, and construction materials such as metal, tile, and grass are far less important than wood in the construction of homes and other buildings. Beyond their immediate importance in furnishing firewood and timber to the people of Okinawa, the forests are also important because they provide a marked opportunity for increased income on the island. Better management of the forest lands seems to promise large returns for small outlays of money and labor. Moreover, much of the

land on Okinawa is better suited for forest production than it is for the growing of grasses or food crops. In this report, the present condition of the forests is indicated and suggestions for improved use and management are offered.

NATIVE FOREST COVER

Though it is impossible now to determine the nature and distribution of the original forest cover, it seems reasonable that the major part of Okinawa was originally covered by trees. The forest was probably absent from the beaches, a few marsh areas behind the beaches, rock ledges upon which trees could not gain a foothold, and perhaps some areas of Regosols (shallow soils) from calcareous clays in the southern part of the island. It is evident that the present forest has been cut over many times. There seems to be no part of the island in which the forest cover has not been disturbed in some way by man. Inferences as to the native vegetation must therefore be made without the study of any virgin forest stands. It does seem reasonable that the original forest cover was approximately comparable to the present stands in composition of species. Broadleaf evergreen species appear to have been dominant in the original forests, with conifers present only as individual trees.

PRESENT CONDITION OF FORESTS

In the mountainous northern part of Okinawa the present forest consists largely of broadleaf evergreen trees. Scattered pine trees are also present but form a very small proportion of the stand. On

some of the moister sites there are occasional Cryptomeria trees among the broadleaf species. From Nago southward to RYCOM the forest is largely of young pine smaller than 6 inches in diameter. Several broad-leafed evergreen shrubs are associated with the dominant pine. On acid soils of low fertility there is a ground cover of fern. In the southern fourth of the island there are only scattered patches of pine or other forest. Here, the vegetation of areas not under cultivation is mostly grass or grass and shrubs.

The forests of Okinawa occupy lands that are either unfit or poor for cultivation. The bulk of the forest occurs in the mountains north of the road that crosses the isthmus from Ishikawa to Nakadomari. There are also fairly large areas of forest in the mountains of central Motobu Peninsula. Forest lands in the southern part of the island are of limited extent, although there are fairly large areas of poor forest in the hilly sections immediately southwest of Ishikawa. About two-thirds, or some 100,000 acres, is in forest at the present time.

The forest is poor and severely overcut. There is no effective management, and production is much less than could be obtained. Very few trees are 10 inches or more in diameter, even in the best areas. The better stands occur in mountain areas which lie two or more miles from a village or which are otherwise difficult to reach. Practically all of the better forest stands can be reached only by footpaths or trails. In the areas near villages, the forest consists largely of saplings or smaller trees, often widely spaced. Perhaps one-half of the forest on Okinawa consists of these relatively poor stands.

This is especially true between Ishikawa and Kawata along the east coast, near Nago, near the villages in the northern third of the island, and on Motobu Peninsula. The stands of these poorer forest areas consist largely but not entirely of young pines mixed with numerous ferns and other non-woody plants. On Red-Yellow Podzolic Soils (acid, relatively infertile soils having light-colored topsoils) along the east coast north of Kawata, the forest stand consists of saplings with a dense undergrowth of dwarf bamboo. This dense undergrowth extends into the mountains in places and may be found in some of the better forest on the acid Lithosols (very shallow soils) from sandstones and phyllites.

SOILS UNDER FOREST

The forests of Okinawa occur mainly in the more inaccessible mountainous areas, which are of light colored acid shallow soils over sandstones and phyllites. These, which are the most extensive soils of Okinawa, are poorly suited to cultivation, even with the mattock and sickle. Furthermore, a major part of the association occurs in mountains which are accessible only with difficulty. For these reasons, the soils are left in forest except near villages where the pressure for food is extreme. Thickness of the soil over rock is commonly less than 12 inches and often as little as 6 or 8 inches. Rarely, it may be as deep as 20 inches, but this is usually on the lower toe slopes where sediments have drifted down from higher areas. The topography is generally mountainous with slopes ranging from 50 to 100

percent. The soils are strongly acid and of low fertility. In spite of these conditions, these soils now support most of the better forests on Okinawa. Presence of the better forests on these soils seems to be due to inaccessibility.

A smaller but important proportion of forest on Okinawa occurs on Red-Yellow Podzolic Soils and Reddish-Brown Lateritic Soils. These soils are deep and physically well suited for plant growth although they are low to only moderate in fertility. Rates of growth on these soils appear to be higher than on the Lithosols.

PRESENT USE AND MANAGEMENT OF FORESTS

Extensive cutting of the forest is now under way on Okinawa; the drain on forest resources seems to have increased sharply since the end of hostilities. The demand for lumber to rebuild homes destroyed during the campaign is especially large. Moreover, there seems to be extensive cutting for firewood and less extensive cutting for charcoal and in the clearing of land. Unusual care in the management of the forests would be necessary under present rates of cutting if forest growth were to approximate the present harvest. Observations made during 1947 indicate that the present rate of cutting far exceeds the rate of forest growth.

The large demand for lumber in the rebuilding of homes seems to have brought about wasteful and destructive practices generally. In places, especially in the pure stands of pine, the forest is being clear-cut without provision for reproduction. In other places, trees

have been cut, sawed into logs, and then left on the ground until attacks by fungi have rendered them useless. There seems to be little systematic harvesting of trees for lumber at the present time and even less thought to long-time forest production.

Wood is the principal fuel used for heating and cooking, and the annual consumption seems to be high for the island as a whole. The harvesting of firewood, like the cutting of logs, is generally haphazard. In some areas, dead and down timber is removed first; in other areas, dead timber is left on the ground while standing trees are cut for firewood. This latter practice is wasteful and seems especially unwise where forest products are needed as badly as they are on Okinawa. Another wasteful practice which is fairly common is that of burning the woods to kill trees and remove underbrush prior to the cutting of firewood. Much of the cutting of firewood seems to be done by members of the family which will use the fuel. There is also, however, much commercial cutting of firewood in northern Okinawa for shipment to the heavily populated southern portion of the island. In this northern section, saplings from two to three inches in diameter are cut in the interior and carried out to the coast to be transported later by ship or truck to Naha and other points in the south. In addition to this use as fuel directly, wood is also used in the making of charcoal. Total quantities of charcoal produced were apparently small during 1947 and 1948.

The clearing of mountain slopes for cultivation is also making local inroads on the forest. Clearing is largely restricted to areas

near villages along the margins of the mountains in the northern half of Okinawa. The total area affected by clearing operations is a small proportion of the land in forest.

A common practice in clearing of land is the use of fire to remove brush and kill the trees, even while people in nearby villages walk several miles into the mountains for firewood. Burning off the brush is much less work than grubbing it out. At the same time, small amounts of plant nutrients contained in the ashes are added to soils of generally low fertility. However, the use of brush fires as an aid in clearing land introduces a fire hazard to the forest in dry seasons. Most of the forest fires observed during the dry season of 1947 appeared to be brush-burning fires that were out of control. The individual fires usually burned over a few acres, but several areas were noticed where as many as 100 acres had been covered by the fire. Some of the fires were hot enough to kill trees 14 inches in diameter. On some steep slopes, fire had jumped into the crowns of the pine trees and killed all of the trees through which it passed. Most of the fires seemed to be due to negligence on the part of the people using fire as an aid in clearing land.

Fortunately, the danger from forest fires on Okinawa is not great. During most years there is only a two-month period when conditions are dry enough to permit extensive burning. Even during that period, showers occur which tend to reduce the possibility of destructive fires. In spite of the showers, however, there is always the possibility that the right weather conditions (low relative humidity and strong winds)

will occur during the dry season and that the whole north part of the island might be burned over before a fire could be checked.

There seems to have been little effort during recent years to provide for the reproduction of the forest or to plant trees. There are a few small plantations of pine or Cryptomeria which evidently were set out before the war. Some of these plantations are now being harvested for timber. During 1947 and 1948, however, there was little evidence of any effort to improve the forest stands or to accelerate the process of reproduction of trees on areas from which timber had been cut.

RECOMMENDATIONS FOR FOREST MANAGEMENT

The observations of the handling of forest on Okinawa during the last half of 1947 and the first part of 1948 indicate that many improvements are possible in management. Present and future production of forest products could be greatly increased by rather simple means. The opportunities for profitable investment of money and time in the improvement of forestry on Okinawa are among the greatest, if not the greatest, on the island. The returns from given amounts of time and money promise to be greater if applied to bettering the forest than they do in other branches of agriculture. Furthermore, labor is the principal item needed for better forestry. A number of recommendations are therefore offered for improving the management of Okinawa forests.

1. The first step in improving present forest management would be the hiring of one or two trained foresters to make a more complete

study of the forests of the island and to offer specific recommendations for use and management of individual tracts of forest land.

2. The clearing of forest from steeper slopes, especially those of 60 percent or more in gradient, should be discouraged. In general, the soils on such slopes are shallow, low in fertility, and poorly suited for crop production. Many of the steeper slopes which have been cleared are badly eroded, less useful now than they formerly were for the production of forest trees, and are entirely unsuited for growing crops.

3. Marked improvements in the harvesting of firewood are possible. Cutting of firewood under proper supervision and regulation can serve to improve the quality and increase the production of timber stands. The harvesting of firewood should be limited to the removal of dead and dying trees, diseased trees, trees with broken or split tops, trees with crooked stems, and trees of undesirable species. Unless practices of this kind are followed in the cutting of firewood, the quality and quantity of timber stands on Okinawa will continue to decline.

4. Systems of forest management best suited to each combination of forest and soil conditions should be worked out and put into effect. Where the stands consist entirely of pines, a seed tree system of management can be followed. Three or four well distributed trees can be left on every acre when the timber is cut. These will then supply an abundance of seed for reforestation of the area. If the soils support a thick cover of grass or brush, controlled burning of this vegetation just before the seeds begin to fall will insure better stocking of the

area. The pines on Okinawa seem to reseed naturally with the same success as that of loblolly pine in the southeastern United States, if they are provided a favorable seed bed.

Some form of selective cutting seems better adapted for the stands of hardwood forest. This would be in addition to the removal of diseased, dead, and otherwise inferior trees for firewood. Where the forests near villages are used exclusively for firewood, selective systems of cutting may be less desirable than a short rotation with clear-cutting and replanting.

5. Establishment of a forest nursery somewhere in the northern part of the island would be highly desirable. This nursery could produce seedlings to replant areas that are now idle but lie too far from seed trees for natural restocking. Nursery stock is also needed for the improvement of stands which are now incomplete.

6. Several species from the United States might well be tried in Okinawa because of their promise as valuable additions to the forests. A few trees of each species should be introduced experimentally to determine whether or not they will make satisfactory growth. Plantings should be restricted to soils similar to those on which the trees grow in the United States. Longleaf pine (*Pinus palustris* Mill) and slash pine (*Pinus caribaea* Morelet), if they can be grown successfully, would be valuable as sources of raw gum from which resin and turpentine could be made. These trees could be tried in experimental plantings on the Lithosols, the Red-Yellow Podzolic Soils, and the Reddish-Brown Lateritic Soils. Loblolly (*Pinus taeda* L.) could also be tried

on these soils. Virginia pine (Pinus virginiana Mill) might prove to be useful in plantings on some of the drier sites, especially on southern and western exposures. Black walnut (Juglans nigra L.) may prove successful and is most likely to thrive on any of the well drained, more fertile soils, especially those underlain by limestone. If the species can be grown successfully, the tree would provide valuable cabinet wood and nuts which would serve as an additional source of food. In addition to the black walnut, the black locust (Robinia pseudoacacia L.) might also be tried on these soils. It would be a source of firewood primarily.

SUMMARY

A major part of the land on Okinawa is now in forest which is potentially its most favorable use. Much of the forest, however, is poorly handled at the present time and is therefore deteriorating. It will continue to deteriorate in the future unless better management practices are adopted. Shortages of many forest products including lumber can be expected in the near future if the present practices continue. On the other hand, forest production on Okinawa might exceed local demand and furnish some items for export under proper management.

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PRELIMINARY GAZETTEER

OF

GEOGRAPHIC NAMES FOR SAIPAN

PREPARED BY
GEOLOGICAL SURVEYS BRANCH
INTELLIGENCE DIVISION
OFFICE OF THE ENGINEER
GENERAL HEADQUARTERS, FAR EAST COMMAND

FEBRUARY 1949

FOREWORD

New topographic maps in preparation by the U. S. Army Corps of Engineers for many of the islands in the western Pacific require a reconsideration of the place names that have been established by the Board of Geographic Names. This is particularly true of the islands of the former Japanese Mandate. Existing maps of these areas carry names in Japanese, English, German, and native spelling; whereas in present day practice, the use of native names is rapidly replacing that of all others. This is consistent with, and an expected consequence of, the Department of Navy's policy in the Trust Territory: to preserve native cultures and customs, to conserve natural resources for the use of the natives, and to encourage greater native participation in island administration.

The following gazetteer of geographic names for Saipan is presented in preliminary form for the consideration of the Board of Geographic Names in establishing a revised decision list for use on maps now in preparation, and also for the immediate local use by the United States Government and native officials in the Trust Territory of the Pacific. The gazetteer was prepared during the course of geologic field work on Saipan, a part of the Pacific Geologic Mapping Program under the direction of the Engineer, Far East Command. The compilations of data extended over a period of three and one-half months and involved extensive interrogation of responsible natives. It is believed that the gazetteer is as accurate in reference to location as native custom with regard to use of geographic names will permit.

Hugh J. Casey

HUGH J. CASEY
Major General, CE

Engineer
General Headquarters
Far East Command

Contents

PRELIMINARY GAZETTEER OF GEOGRAPHIC NAMES FOR SAIPAN*

Introduction

The list of geographic names here presented was compiled from information provided by native residents of Saipan and from published sources**. The approximate locations to which the names apply are shown on the accompanying five overlays entitled, "Preliminary Native Geographic Names for Saipan." These overlays are to accompany "Special Map, Saipan-Tinian Area, Scale 1:20,000, 64th Engineer Topographic Battalion, USAFICPA, April 1944." Roads and installations are not shown on the present map, in order not to obscure the names, and for reasons of military security.

The preferred terminology given is entirely in the Chamorro language as written and spoken on Saipan; except for the names of the roads, which are given in English. This policy was agreed upon in joint conference with Captain G. L. Compo, Island Commander; Colonel H. P. Detwiler, Commanding Officer, Army Garrison Forces; Commander F. L. Sheffield, Civil Administrator; Major A. C. Reade, the retiring Post Engineer; Lieutenant (senior grade) J. N. Hightower, Jr., Economics Officer of the Civil Administration; and Mr. Vicente Guerrero, Public Safety Official of the Civil Administration.

1912-

*This report was prepared by Preston E. Cloud, Jr., geologist, U. S. Geological Survey, on loan to the Office of the Engineer, General Headquarters, Far East Command, and chief of the Marianas field party.

**For enumeration of sources used in this report, see the topics "Organization of the Gazetteer" and "Essential Rules of Chamorro Grammar, Spelling, and Pronunciation Relating to Geographic Names."

The gazetteer and the accompanying map have been checked and approved by members of the group named above, as well as by Chief Elias B. Sablan, Mayor of Chalan Kanoa, and by Mr. William Reyes, Superintendent of Native Schools on Saipan (See Appendix 1.).

The author is most grateful for the help of those persons named above, as well as that of Messrs. Ramon Borga and Benignio Sablan, who reviewed the place names in the field with the author; Mr. Benusto Reyes, who functioned as interpreter; and Miss Florence J. Flatt, who took notes of field and office conferences with native informants and helped with the arrangement of the gazetteer.

Organization of the Gazetteer

Names are given in the alphabetic sequence of the localizing geographic word which is used as an index word; thus Laderan Tagpochau (Tagpochau Cliffs) is listed under "T", and Unai Afetña (Afetña Beach) is listed under "A". Where the same localizing name applies to different features, the sequence under this name is in the alphabetical order of the feature-name; thus Achugau, Laderan Achugau, Puntan Achugau, Sabanan Achugau, and Unai Achugau come in that order under "A".

The preferred name, followed by its nearest English translation, is given in the left-hand column of the gazetteer, and other names that have been or are at present applied to the same locality are given in the right-hand column. Only different localizing geographic words or variant spellings are considered in the right-hand column.

Because present roads on Saipan do not strictly adhere to the former pattern of native roads, and because of various eccentricities in

native terminology for roads, the recommended names for roads are in English, as given on the "Road Map, Island of Saipan", issued by the Public Works Department, Naval Operating Base, Saipan, on 5 September 1947. These are listed at the end of the gazetteer, with only slight modifications in conformity with native spellings. This procedure was agreed to and recommended by the native authorities mentioned above. Neither the roads nor their names are shown on the map that accompanies the present gazetteer.

The gazetteer excludes names of all military and related installations, as these are of concern solely to the occupation forces. Such names will be added to the final topographic and geologic and soils maps of Saipan, as applicable on date of final compilation and as usable without violation of security regulations.

English Meaning of Key Geographic and Modifying Words

Only 21 Chamorro words need be learned in order to read the gazetteer and map as easily as though it were in English, and 6 of these are so similar to the English word as to be of obvious meaning. In addition to the key words listed, it is convenient in inquiring locally for information to know the Chamorro words for east (haya, pronounced haza) and west (lagu). The Chamorro word chalan means road, but it is used in the present gazetteer only where combined with another word in areal designation, and such combined words are listed alphabetically under "C". The 21 key words are listed below.

Chamorro	English Meaning
As	The place (or house) of; at, in, to, or through the place of
Bahia	Bay
Bobo	Spring
Dangkulo	Big
Dikiki	Little
Hagoi	Lake
Hoyon (pronounced hō'zän)	Large sink (possessive of hoyo)
I	The, that, this (the definite article)
Isleta	Small island
Kanat	Ravine
Katan	North
Laderan	Cliff or cliffs (possessive of ladera)
Lagunan	Lagoon (possessive of laguna)
Liyang (pronounced li'zang)	Cave
Luchan	South
Ogso	Mountain, hill, or ridge
Puetton	Harbor (possessive of puetto)
Puntan	Point (possessive of punta)
Sabanan	Natural grassland (possessive of sabana)
Sadog	Fresh water, or a ravine inwhich fresh water occurs
Unai	Beach (literally means sand, sometimes spelled inai)

Essential Rules of Chamorro Grammar, Spelling, and Pronunciation Relating to Geographic Names

Here will be considered very briefly a few rules of grammar and enunciation as applies specifically to simple geographic terminology. The writer himself is not conversant with the language, his sources of information being Messrs. William Reyes, Elias B. Sablan, and Vicente Guerrero of Chalan Kanoa; and the Chamorro-Wörterbuch, by P. Callistus, O. Capuc., publishedby Typio Societatis Missionum ad Exteros, Hongkong, 1910. This reference includes 172 quarto pages of German-Chamorro and Chamorro-German dictionary, and a 33-page index of Chamorro grammar and common queries and phrases translated into German. This dictionary is recommended to those interested in more detail than is given here. Unfortunately it seems to be a rare item, as is a similar book reported to have been prepared by a Spanish priest (and written in Spanish) but not seen by the author of this report.

Articles. There is no true indefinite article in the Chamorro language. However, the Spanish un has been adopted and at present applies to both masculine and feminine nouns: thus un lahe (a man) or un palauan (a woman).

The definite article is invariably i, and the first vowel of words following i is commonly altered by its presence: thus donni becomes i denni, lusong becomes i lisong, and fădung becomes i fĕdung. Ordinarily it is used with appropriate place names (I Denni, I Pitot, etc.), but in some instances it is omitted (Afetña, not I Afetña).

Directions. Katan, luchan, haya, and lagu are the Chamorro words for north, south, east, and west, but when spoken they (as well as other

words for directions; such as up, down, in, out) are preceded by the word san, meaning approximately, "toward the side." Thus san katan means toward the north side, etc. But san affects the initial vowel as does i, and kä'tän becomes san kă'tän, luchan becomes san lichan, and haya (hä'za) and lagu (lä'gu) also take the short initial ă following san.

Other modifying words. Some words add a terminal n to show possession: thus ladera, punta, and sabana become Laderan, Puntan, and Sabanan where applied to some particular cliff, point, or area of natural grassland.

As indicates possession and is a nearly invariable prefatory word in areal names derived from family names of former (rarely present) residents. The native designation of such land areas is much like that in parts of the rural United States. The "old Smith place" and "the Ledbetter place" would be As Smith or As Ledbetter in Chamorro, and different generations of neighbors might likely have different concepts of their limits and extent. In a few instances As is, through custom, omitted and the family name stands alone (for example, Gallego, not As Gallego).

Accent. Chamorro accent is generally as in Spanish, but if one accents as he would in English and gets the syllabic pronunciation essentially correct he will ordinarily be understood.

Pronunciation and spelling. A few rules of pronunciation will suffice for present purposes:

An initial y is pronounced as y, but y preceding a vowel takes on the sound of z, or more accurately, a zy sound (as in liyang).

In a few exceptions the y is pronounced as a j (Reyes).

Pronounce o as u in terminal syllable (madog, sadog).

A terminal g partakes of a c sound (madog, sadog).

An initial s partakes of a z sound in some words (sadog) but not ordinarily (not in susu, sabanan, sisonyan).

The sound tch is represented in Chamorro by ch.

The letter c is not properly used in the Chamorro language except preceding h to give the tch sound or when followed by e or i and pronounced as s (Merced, gracia). Both the c and k sounds are represented by k, and words taken over from other languages are altered accordingly: thus calabera (Spanish for skull) becomes kalabera in Chamorro.

The use of accent signs is not consistent; thus sabana omits the tilde but maña retains it.

If there is a doubt, a soft enunciation is ordinarily preferable.

Peculiarities of Chamorro Geographic Terminology

In some senses the Chamorro tongue expresses subtleties for which the English tongue has no exact counterparts, but in other senses words may be of confusingly broad application. The word sadog appears to apply primarily to a ravine or valley along whose course flowing fresh water may be found at most times, yet it is also used to apply to any specific occurrence of fresh water, such as a spring. The word bobo, on the other hand, applies specifically to a spring, but appears to be less commonly used than sadog. In the gazetteer bobo is used for

a fresh-water spring and sadog for a ravine in which fresh water occurs. Natural grasslands, wherever they occur or once occurred, are designated as sabanan, and are differentiated from adjacent woodlands or halum-tano. Tase means any salt water, whether ocean, bay, or lagoon, and the Spanish words bahia and laguna were incorporated in the language to give it precision here; yet the geographic name of the adjoining shore is commonly combined with tase to designate particular but unbounded stretches of salt water. Sadog Tase is then a peculiar combination referring to a brackish inlet and the stream leading inland from it at the south margin of Tanapag (tän ä' päg). The Chamorros have a word for mountain or hill, ogso, but those on Saipan, at least, apparently seldom use it and rarely bother to name a hill or mountain as distinct from the general land area in which it lies.

Land Boundaries

Boundaries between land units rarely are well-defined except where formed by cliffs, ravines, or the sea. In earlier days Saipan is reported to have been largely forested, except for sword-grass (Miscanthus) sabanas in areas of volcanic outcrop, and land boundaries ran through the jungle between conspicuous trees agreed upon as property corners. With the eradication of the ancient jungle growth over large areas, these natural boundary markers are mostly gone, and commonly memory alone serves to recall where many of the old boundaries were.

The Japanese blocked off the land into a number of districts

with definite boundary lines and mostly designated by their phonetic rendition of certain native names; but the native Chamorros do not recognize the Japanese boundaries, and the establishment of definite lines between the native land districts on the island will be a major cartographic and civic problem. Most of the Japanese names bore some resemblance to the native names, and are included as alternate names in the gazetteer. However, the Japanese also recognized four major administrative districts not corresponding to any native land districts and not listed in the gazetteer. These were Galapan Cho (Garapan District), Charanka Cho (Chalan Kanoa District), Minami Mura (South Township), Higashi Mura (East Township), and Kita Mura (North Township).

It is believed that the district names given in the present gazetteer and on the accompanying map are as nearly correct as is possible and that they are located in approximately the right positions. They serve the Chamorro as recognized land districts, however indefinite their boundaries; and accurate location of the boundaries is a problem for the surveyor and the eventual local administration. The location of named natural features such as cliffs, ravines, streams, mountains, and hills is, of course, known as precisely as the terminology applies.

The Gazetteer

Preferred Name (the Chamorro name or that used by Chamorros; index word underlined)	Nearest English Meaning	Other Names (that have been, or are, applied to same locality)
Achugau: Achugau	Gleichenia (district; from the xerophytic fern Gleichenia)	Atchugau, Atchugao, Sankakuyama
Laderan Achugau	Gleichenia Cliffs	
Ogso Achugau	Gleichenia Mountain	
Puntan Achugau	Gleichenia Point	
Sabanan Achugau	Gleichenia Grasslands	
Unai Achugau	Gleichenia Beach	
Adelug: Laderan Adelug	Sloping Cliffs (the descending part of a slope)	
Afetña: Afetña	Abdomen (district)	Hafetña, Aphenia
Puntan Afetña	Abdomen Point	Puntan Chalan Piao
Unai Afetña	Abdomen Beach	Yellow Beach
Agag: I Agag	The Pandanus (district; from the tree, Pandanus)	
Laderan I Agag	Pandanus Cliffs	
Agaton: Sadog As Agaton	Agaton Ravine (from a family name)	
Agingan: Agingan	Agingan (district; meaning unknown)	Ageegan
Laderan Agingan	Agingan Cliffs	
Puntan Agingan	Agingan Point	Afetña, Hafetña
Unai Dangkulo Agingan	Large Agingan Beach	White No. 1 Beach

Preferred Name	Nearest English Meaning	Other Names
Akina: As Akina	Akina Place (district; from a family name)	Asakina
Sabanan As Akina	Akina Grasslands	
Apicot: Kanat I Apicot	Apicot Ravine (meaning unknown)	Iapicot, Canal-Daut
Banadero: Bañadero	Cattle Wallow (district)	Banaderu, Banadel
Laderan Bañadero	Cattle Wallow Cliffs	
Bapot: Puntan Bapot	Steamship Point	Vapot
Unai Bapot	Steamship Beach	Purple No. 2 Beach
Chacha: Chacha	Lovely, Elegant (district)	Tsatsa
Chalan Kanoa:		
Chalan Kanoa	Canoe Road (village)	Chalanka, Chalan-Kanoa, Charan Kanoa, Charan Ganoa
Hagoi Chalan Kanoa	Canoe Road Lake	Hagoy Chalan Kanoa, Susupe, Susube, Sussupe
Lagunan Chalan Kanoa	Canoe Road Lagoon	
Unai Chalan Kanoa	Canoe Road Beach	Blue Beach plus Green No. 3 Beach
Chalan Kiya:		
Chalan Kiya	Ship Keel Road (village)	Chalan Killa, Charan Killa, Chalan Kesa, Charan Kesa, Charankesa, Chalankesa, Chalan Keza, Chalankeza, Charan Keza, Charankeza.

Preferred Name	Nearest English Meaning	Other Names
Chalan Kiya (continued):		
Unai Chalan Kiya	Ship Keel Beach	Red Beach plus Green Nos. 1 and 2 Beaches
Chalan Laulau:		
Chalan Laulau	Trembling Road (district)	Laolao, Raurau
Chalan Piao:		
Chalan Piao	Bamboo Road (district)	
Chalan Pupulo:		
Chalan Pupulo	Pepperleaf Road (district)	
Dago: Dago	Yam (district)	
Laderan Dago	Yam Cliffs	
Dandan: Dandan	Ringing (or playing a musical instrument) (district)	
Laderan Dandan	Ringing Cliffs	
Puntan Dandan	Ringing Point	
Sabanan Dandan	Ringing Grasslands	
Unai Dandan	Ringing Beach	
Daog: Kanat I Daog	Calophyllum Ravine (from the tree, Calophyllum)	Idaog
Laderan I Daog	Calophyllum Cliffs	

Preferred Name	Nearest English Meaning	Other Names
Denni (possessive of Donni): I Denni	Red Pepper (district, which includes I Pitot and I Lisong as subdistricts; in part sometimes referred to as Chalan I Denni)	Donni, Donnay, Donnii, Dongnay, Idnene, Idenne
Bobo I Denni	Red Pepper Springs	
Sadog I Denni	Red Pepper Stream	
Dogas: Ogso Dogas	Strombus Mountain (from a small species of the gastropod Strombus, aff. S. ustulatus Schumacher)	Mt. Asumaitok
Puntan Dogas	Strombus Point	
Sadog Dogas	Strombus Stream	
Donni (see Denni)		
Eddot (possessive of Oddot): Kanat I Eddot	Black Ant Ravine	Eddot, Ieddot, Oddot, Yed
Sabanan I Eddot	Black Ant Grasslands	
Fadang: I Fadang	Cycad (district; from the cycad, a plant intermediate in appearance between a fern and a palm)	Ifadang
Fahang:		
Isleta Maigo Fahang	Sleeping Sea Bird Islet (from a small, dark sea bird, not identified)	Tsukimi Island

Preferred Name	Nearest English Meaning	Other Names
Fahang (continued):		
Kanat Fahang Katan	North Sea Bird Ravine	Kanat Unai Fahang, Fahan
Kanat Fahang Lichan	South Sea Bird Ravine	
Sabanan Fahang	Sea Bird Grasslands	Sabanan Unai Fahang
Unai Fahang	Sea Bird Beach	
Falingun Hanum:		
Liyang Falingun Hanum	Cave of Disappearing Water	Falingun Hanum
Falipe: As Falipe	Falipe Place (district; from a corruption of Felipe, name of a former Spanish Governor)	Falipe
Kanat Falipe	Falipe Ravine	
Fanaganam:		
Kanat Fanaganam Katan	North Bottleneck Ravine (word applies to a narrow place between cliffs where hunters ambush game)	Fanagahnam
Kanat Fanaganam Lichan	South Bottleneck Ravine	
Laderan Fanaganam	Bottleneck Cliffs	
Fañunchuluyan:		
Fañunchuluyan	Place of Catching Fish with a Large Net (district)	Faninchuluyan, Hanachiruzan, Hanatilizan
Bahia Fañunchuluyan	Fish Net Bay	Tsukimishima Bay
Kanat Fañunchuluyan	Fish Net Ravine	
Puntan Fañunchuluyan	Fish Net Point	
Unai Fañunchuluyan	Fish Net Beach	

Preferred Name	Nearest English Meaning	Other Names
Fina-sisu: Fina-sisu (sisu is possessive of susu)	Shape of a Breast (district)	Finasisu, Finasusu, Hinashisu
Flores: Puntan Flores	Flower Point	
Frailan:		
Kanat As Frailan	Frailan Ravine (from a family name)	
Gallego:		
Sabanan Gallego	Gallego Grasslands (from a family name)	Sabanan As Tama
Garapan: Garapan	Beach Grass (district); from a strandline plant, corruption of the Carolinian word arabul)	Galapan; in part Chalan Nuebo, Chalan Nuevo, or Charannehp
Lagunan Garapan	Beach Grass Lagoon	
Unai Garapan	Beach Grass Beach	
Gloria: Puntan Gloria	Glorious Point	
Gonno: As Gonno	Gonno Place (district); from a family name)	Asgonno, Asgono, Asukon, Askonno
Laderan Gonno	Gonno Cliffs	
Gualo Rai: Gualo Rai	King's Farm (district)	Gualorai, Guarorai, Guarolai
Ogso Gualo Rai	King's Farm Hill	

Preferred Name	Nearest English Meaning	Other Names
Hagman: Laderan Hagman	Eel Cliffs (from a small marine eel, not identified)	Kagman, Kagaman
Puntan Hagman	Eel Point	
Sabanan Hagman	Eel Grasslands	
Unai Hagman	Eel Beach	
Halaihai: Halaihai	Beach Lily (district)	Alihahi
Kanat Halaihai	Beach Lily Ravine	
Puntan Halaihai	Beach Lily Point	
Unai Halaihai	Beach Lily Beach	Brown No. 2 Beach
Hasngot: I Hasngot	Spice-root (district; from plant with a yellow spicy root, not identified)	Hasngug, Hashngug
Sadog I Hasngot	Spice-root Stream	
Unai I Hasngot	Spice-root Beach	
Ifa (possessive of Ufa): Laderan I Ifa	Ufa Cliffs (named for the large tree called Ufa, not identified)	
Kalabera: Kalabera	Skull (district; area was location of last battle between Chamorros and Spanish)	Kalaberan Lichan, Calabera, Galaperai, Calabela, Karabena, Karabela
Laderan Kalaberan Katan	North Skull Cliffs	
Laderan Kalaberan Lichan	South Skull Cliffs	Petosukara (includes three top terraces of this vicinity)

Preferred Name	Nearest English Meaning	Other Names
Kanoa (see Chalan Kanoa)		
Kiya (see Chalan Kiya)		
Lagua: Laderan Lagua	Net Cliffs	Laderan Unai Lagua
Puntan Lagua Katan	North Net Point	Puntan Unai Lagua Katan, Puntan Bañadero
Puntan Lagua Lichan	South Net Point	Puntan Unai Lagua Lichan, Inanasu, Puntan Bañadero
Unai Lagua	Net Beach	
Laremies: Kanat Laremies	Laremies Ravine (meaning unknown)	
Laulau: Laulau	Tremble (district)	Laolao, Raurau
Bahia Laulau	Trembling Bay	Laulau Tase, Magicienne Bay
Kanat Laulau	Trembling Ravine	
Kanat Tadung Laulau	Trembling Deep Ravine	
Laderan Laulau	Trembling Cliffs	
Laulau Katan	North Tremble (district)	Rorogattan
Puntan Laulau Katan	North Trembling Point	
Sabanan Laulau	Trembling Grasslands	
Unai Laulau	Trembling Beach	Purple No. 1 Beach
Unai Laulau Katan	North Trembling Beach	
(see also Chalan Laulau)		

Preferred Name	Nearest English Meaning	Other Names
Lisong (possessive of Lusong): I Lisong	The Mortar (a sub-district of I Denni)	Lisung, Lisong, Ilisong
Lito: As Lito	Lito Place (district); from a proper name, Louis)	Ashlito, Asurito, Asleet
Hoyon As Lito Katan	North Lito Sink	
Hoyon As Lito Lichan	South Lito Sink	
Liyang (possessive of Luyang): I Liyang	The Cave (district)	Liyang, Lizang
Luau: Isleta Maigo Luau	Sleeping Sea Bird Islet (from a large, dark sea bird, unidentified)	
Lusong (see Lisong)		
Luyang (see Liyang)		
Machegit:		
Laderan Machegit	Compressed Cliffs (word means to crowd, squeeze, or clump together)	
Madog: I Madog	The Hole (applies to a cave-sink and also the surrounding district)	
Laderan I Madog	The Hole Cliffs	
Puntan I Madog	The Hole Point	

Preferred Name	Nearest English Meaning	Other Names
Magpi: Magpi	Magpi (district; meaning unknown)	Matpit, Marpi, Mappi
Kanat Magpi	Magpi Ravine	
Laderan Magpi	Magpi Cliff	
Puntan Magpi	Magpi Point	Toro
Unai Magpi	Magpi Beach	Orange Beach
Mahetog: As Mahetog	Mahetog Place (district; presumably from a family name or nickname; means hard)	Asmahettog, Asumitok
Kanat Tadung Mahetog	Mahetog Deep Ravine	
Mamis: Sadog Mamis	Sweet Stream	
Mañagaha:		
Isleta Mañagaha	Island of the Wily Ones	Maniagassa, Maniagawa, Battleship
Matansa: Matansa	Slaughter (district; the place where the Spanish broke through Chamorro lines, before the final battle of Chamorro resistance at Kalabera)	
Matuis: As Matuis	Matuis Place (district; from a family name)	Matoisa
Unai Dikiki Matuis	Little Matuis Beach	North end of Black No. 1 Beach
Muchot: Puntan Muchot	Pouting Point (a corruption of muyo, meaning to pout)	Mutcho, Mucho, Pontamcho

Preferred Name	Nearest English Meaning	Other Names
Naftan: I Naftan	The Grave (district)	Nafutan
Laderan I Naftan	Grave Cliffs	
Puntan I Naftan	Grave Point	
Nanasu: Kanat Nanasu	Nanasu Ravine (from a small strand-line medicinal tree, not identified)	Kanat Unai Nanasu, Kanat Inanaso
Puntan Nanasu	Nanasu Point	
Sabanan Nanasu	Nanasu Grasslands	Sabanan Unai Nanasu
Unai Nanasu	Nanasu Beach	
Obyan: Obyan	Obyan (district; meaning unknown, corruption of the old Carolinian word obian)	Obzan, Ofsam, Obiam, Obiamu, Obeejan
Laderan Obyan	Obyan Cliffs	
Puntan Obyan	Obyan Point	Puntan Unai Dangkulo
Puntan Unai Obyan	Obyan Beach Point	
Unai Obyan	Obyan Beach	White No. 2 Beach
Oddot (see Eddot)		
Oleai: Oleai	Oleai (district; name from a district or group of islands in the Carolines. Settled by Carolinians about 1908)	Uleai, Oleay, Oreai
Palacios: As Palacios	Palacios Place (district; from a family name)	Palacios

Preferred Name	Nearest English Meaning	Other Names
Palomo: As Palomo	Palomo Place (district; from a family name)	Aspalomo, Agpalomo
Papago: Papago	Nettle Rash (district)	Papako, Pahpago
Papau: Kanat Papau	Bitter-root Ravine (from an unidentified thorny plant with an inedible root)	
Laderan Papau	Bitter-root Cliffs	
Unai Papau	Bitter-root Beach	Black Beach (in part)
Peo: Unai Peo	Peo Beach (from a proper name, Joe)	
Perdido: As Perdido	Perdido Place (district; presumably from a family name; means lost, ruined, spoiled)	Asperdido, Asberded
Piao (see Chalan Piao)		
Pidos Kalahe:		
Pidos Kalahe	The Bottom of the Inverted Kettle (a mountain)	Mt. Magpi
Pitot (possessive of putot): I Pitot	The Pestle (a subdistrict of I Denni)	
Kanat I Pitot	The Pestle Ravine	
Puerto Rico: Puerto Rico	Rich Port (district)	Sadokutushiji, Portaligo
Pupulo (see Chalan Pupulo)		

Preferred Name	Nearest English Meaning	Other Names
Putot (see Pitot)		
Rapugau: As Rapugau	Rapugau Place (district; from a family name)	Rapugau, Rapogao, Lapagao, Lapgao
Kanat Tadung Rapugau	Rapugau Deep Ravine	
Sabanan Rapugau	Rapugau Grasslands	
Rueda: Kanat Rueda	Wheel Ravine	
Laderan Rueda	Wheel Cliffs	
Sabaneta: Sabaneta	Small Grasslands (district)	
Puntan Sabaneta	Small Grasslands Point	Toro, Magpi
Susupe: Susupe	Rip Current (district)	Sussupe, Susube
Hagoi Susupe	Rip Current Lake	Hagoy Susupe, Hagoi Chalan Kamoi, Hagoy Chalan Kanoa, Susupe, Susube, Sussupe
Puntan Susupe	Rip Current Point	Afetña Point
Tablan:		
Kanat Tablan Katan	North Table Ravine	
Kanat Tablan Lichan	South Table Ravine	
Tagpochau: Tagpochau	Springing Up Beyond Another (district; a corruption of tag-pechau)	Tapotchau, Tappocho, Tapocho, Tagpechau
Laderan Tagpochau	Upspringing Cliffs	
Ogso Tagpochau	Upspringing Mountain	

Preferred Name	Nearest English Meaning	Other Names
Talofofo: Talofofo	Middle Spring (district; a corruption of talona-bobo)	Tarahoho, Radio Hill, Telegraph Hill, Densinyama
Ogso Talofofo	Middle Spring Ridge	
Sabanan Talofofo	Middle Spring Grasslands	
Sadog Talofofo	Middle Spring Stream	
Unai Talofofo	Middle Spring Beach	
Taman: Laderan As Taman	Taman Cliffs (from the family name, Tama)	
Tanapag: Tanapag	Tanapag (district; meaning unknown)	Tanabaco
Lagunan Tanapag	Tanapag Lagoon	
Puetton Tanapag	Tanapag Harbor	Tanapag Port
Unai Tanapag	Tanapag Beach	Scarlet No. 1 Beach
Tanke: Tanke	Cistern (district)	
Laderan Tanke	Cistern Cliffs	Petosukara, Jap Hill
Puntan Tanke	Cistern Point	Puntan Kalabera
Tase: Sadog Tase	Salt-water Stream	Tasi
Unai Sadog Tase	Salt-water Stream Beach	Scarlet No. 2 Beach (in part)
Teo: As Teo	Teo Place (district; from a family name	Finasisu As Teo
Liyang As Teo	Teo Cave	

Preferred Name	Nearest English Meaning	Other Names
Tipo Pale (Tipo is possessive of Tupo):		
Ogso Tipo Pale	Priest's Well Mountain	
Trinchera: Trinchera	Entrenchment (Point)	Puntan Trinchera
Tupo (see Tipo Pale)		
Tuturam: Tuturam	Clean-washed (district; from the Carolinian tutu, bathes, plus ram, clean)	Tsutsuram, Tsutsuman, Todlan
Unai Tuturam	Clean-washed Beach	
Ufa (see Ifa)		

Roads

Chalan is the Chamorro word for road, and there are many Chamorro names for roads on Saipan. Most of these have been omitted, as the local refinements involved are commonly more confusing than helpful. Chalan is also used as a prefix to indicate some place from or to which some road ran to or from another place. That the road or roads are no longer in existence does not seem to interfere with the local use of Chalan, and in this instance, therefore, the English word road is preferred by all consulted.

Preferred Name	Other Names
Beach Road	
Cross-island Highway	Chalan Donni
East Coast Highway	
Fina-sisu Road	Finasisu
Five-hundred Pit Road	
Golf Course Road	
Hagman Field Road	Kagman Road
Isley Entrance Road	
Isley Perimeter Road	
As Lito Road	Chalan As Lito
Little Burma Road	
Matuis Road	Matoisa
Navy Drive	
As Perdido Road	Chalan As Perdido, Aspedido
Power Plant Drive	

Preferred Name	Other Names
Rocket Area Road	
Sugarmill Road	
Tagpochau Road	Tapotchau, Tapochau, Tagpechau
Talofofo Road	Tarahoho
Terminal Road	
Texas Road	
Twin Pines Road	
Village Road	
Wallace Highway	Chalan Dandan
West Coast Highway	

APPENDIX 1.

The attached "Gazetteer of Geographic Names for Saipan," dated 7 February 1949, and the map that accompanies it, has the approval of the undersigned as regards policy and the specific geographic terminology applied.

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Pacific Geological Surveys
Military Geology Branch, U.S.G.S.
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Partially Edited

BIBLIOGRAPHY OF THE GEOLOGY OF KARAFUTO

Edited by Dr. Yasuo Sasa

1. For the convenience of geological scholars of Sakhalin Island, literature related to the geology of Sakhalin is listed.

2. The books listed are confined to those treating geology; those related to mining are not included. The selection was based on the judgment of the editor.

3. The editor has investigated far and wide to the best of his ability, but he is still not confident that he has listed all the books. Some important ones may have been missed, especially the Russian books. The editor will do his utmost to supplement the list by the additional information submitted by the public.

4. This bibliography lists those publications through 1937. Unpublished books and manuscripts such as the reports by the Mineral Industries Section of the Government General of Karafuto, the Geological Institute, the Ministry of Commerce and Industry, the theses of the geological institutes of universities and survey reports by companies interested with coal and oil industries are all excluded because they are not available to the general public.

5. The books are arranged in alphabetical order by names of the authors listed according to Japanese style "romaji" unless the author has already spelled his name by another system. Several books by the same author are listed in chronological order. In the case of joint authorship only the first named author is listed alphabetically.

6. It is a great pity that the editor has been unable to specify the volume, the number, the page etc., of some books listed herein because he has hae no opportunity to check for himself. Information from readers will be appreciated.

7. The editor is grateful for the helf pf many people, especially Mr. J. Shintani, Mr. J. Suzuki, Mr. T. Nagao, Mr. K. Kamitoko, Mr. M. Kawasaki, Mr. M. Kaneko, Mr. S. Oishi, Mr. H. Takeda, Mr. S. Nisida, Mr. B. Sonoda, Mr. K. Fujioka, Mr. T. Inoue, Mr. S. Masubuchi, Mr. M. Funahashi, Mr. M. Minato, Mr. I. Natsui, Mr. T. Yamada, Mr. R. Fukaya and Mr. K. Hirano. The editor expresses his deepest gratitude for their assistance.

A

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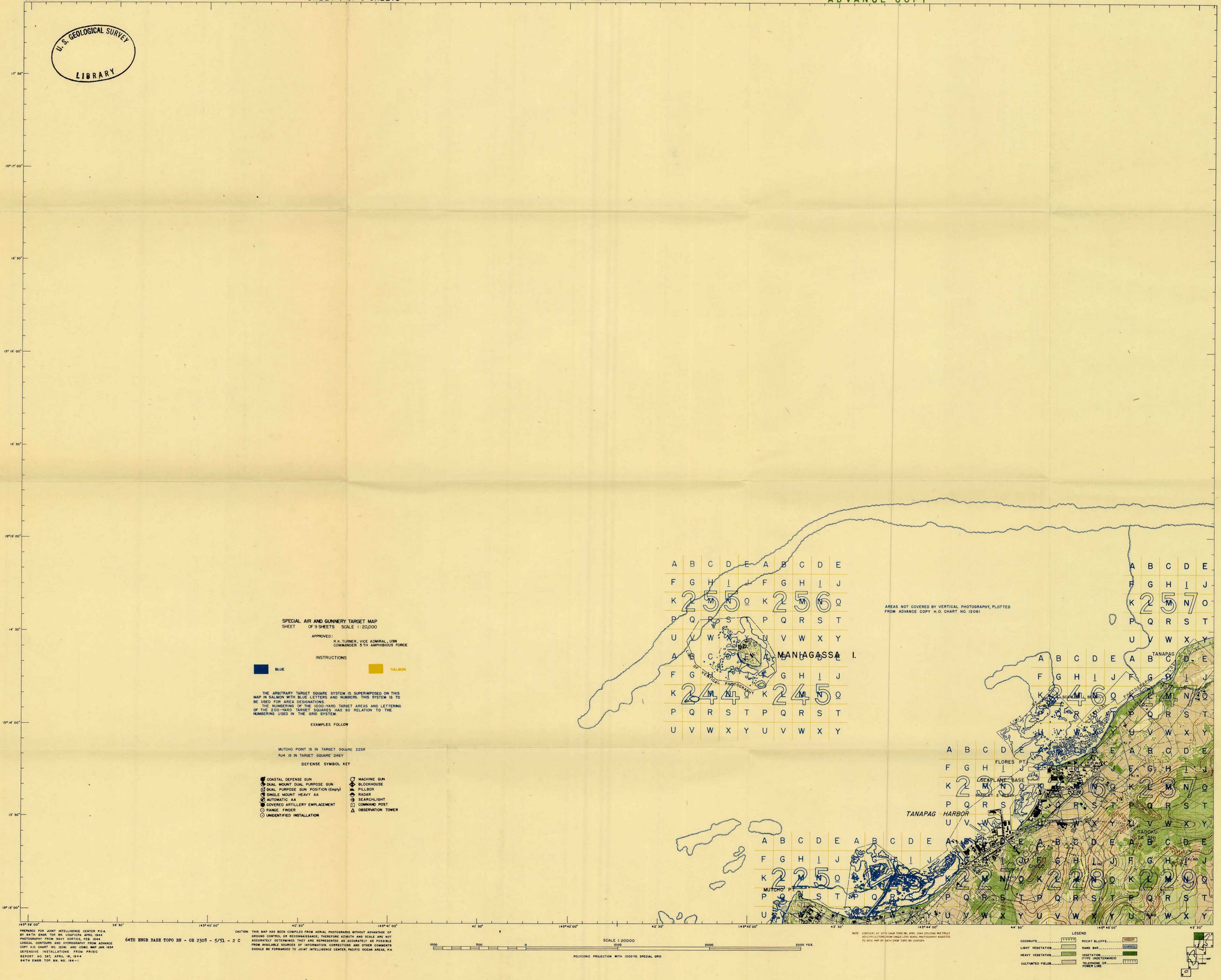
SAIPAN – TINIAN AREA
SHEET 1 OF 9 SHEETS
SPECIAL MAP
ADVANCE COPY
RESTRICTED



SAIPAN – TINIAN AREA

17' 30"

15° 17' 00"

16' 30"

15° 16' 00"

15' 30"

EETS

SPECIAL MAP

RESTRICTED

ADVANCE COPY

15°15' 00"

14' 30"

15° 14' 00"

13' 30"

15° 13' 00"

145° 39' 00" 39' 30" 145° 40' 00" 40' 30" 14

SPECIAL AIR AND GUNNERY TARGET MAP

SHEET OF 9 SHEETS SCALE 1 : 20,000

APPROVED:

R.K. TURNER, VICE ADMIRA
COMMANDER 5 TH AMPHI

INSTRUCTIONS

BLUE

THE ARBITRARY TARGET SQUARE SYSTEM IS SUPERIMPOSED MAP IN SALMON WITH BLUE LETTERS AND NUMBERS. THIS SYSTE BE USED FOR AREA DESIGNATIONS.

THE NUMBERING OF THE 1000-YARD TARGET AREAS AND L OF THE 200-YARD TARGET SQUARES HAS NO RELATION TO NUMBERING USED IN THE GRID SYSTEM.

EXAMPLES FOLLOW

MUTCHO POINT IS IN TARGET SQUARE 225R

RJ4 IS IN TARGET SQUARE 246Y

DEFENSE SYMBOL KEY

- COASTAL DEFENSE GUN
- DUAL MOUNT DUAL PURPOSE GUN
- DUAL PURPOSE GUN POSITION (Empty)
- SINGLE MOUNT HEAVY AA
- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GU
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGH
- COMMAND PO
- OBSERVATION

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
COPY H.O. CHART NO. 12061 AND U.S.M.C. MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
REPORT NO. 387, APRIL 18, 1944
64TH ENGR. TOP. BN. NO. 194-1

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTA GROUND CONTROL OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE AR ACCURATELY DETERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POS FROM AVAILABLE SOURCES OF INFORMATION. CORRECTIONS AND OTHER COM SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN ARE

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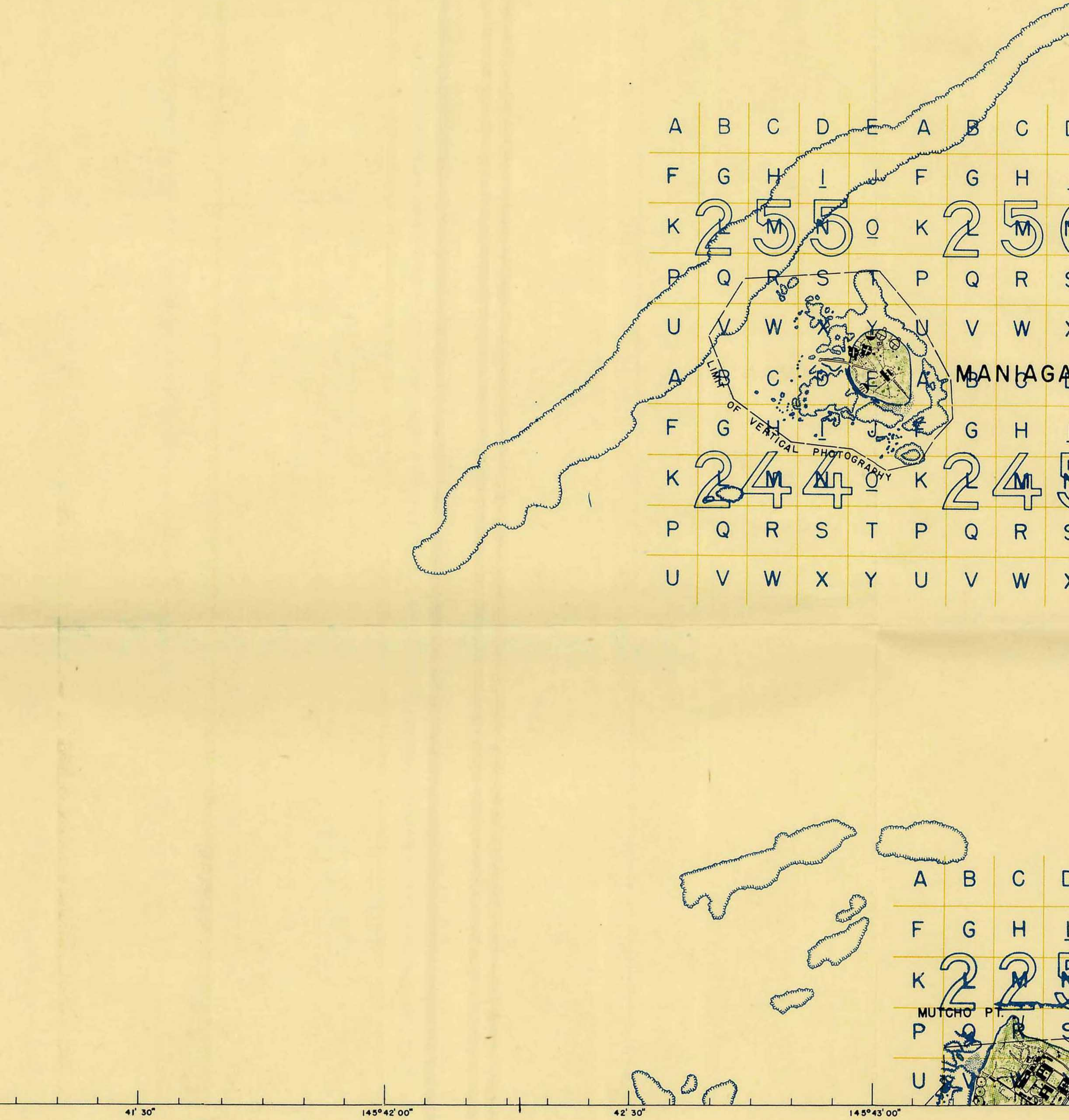

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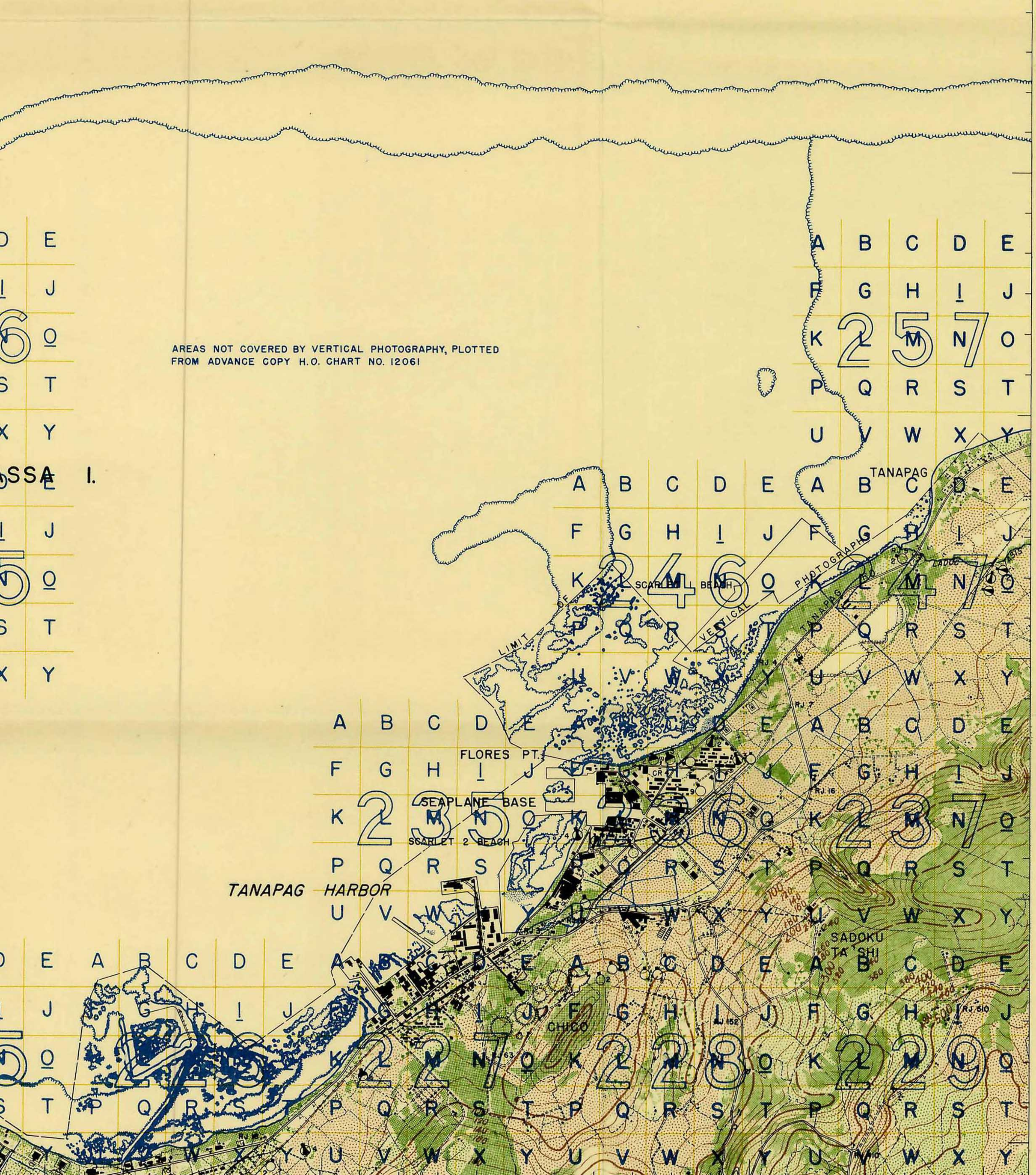
SCALE 1:20000

1000 500 0 1000 2000 3000 YDS.

POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID



NOTE CONTOURS BY 29TH ENGR TOPO BN, APRIL 1944 UTILIZING MULTIPLEX AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY ADJUSTED TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

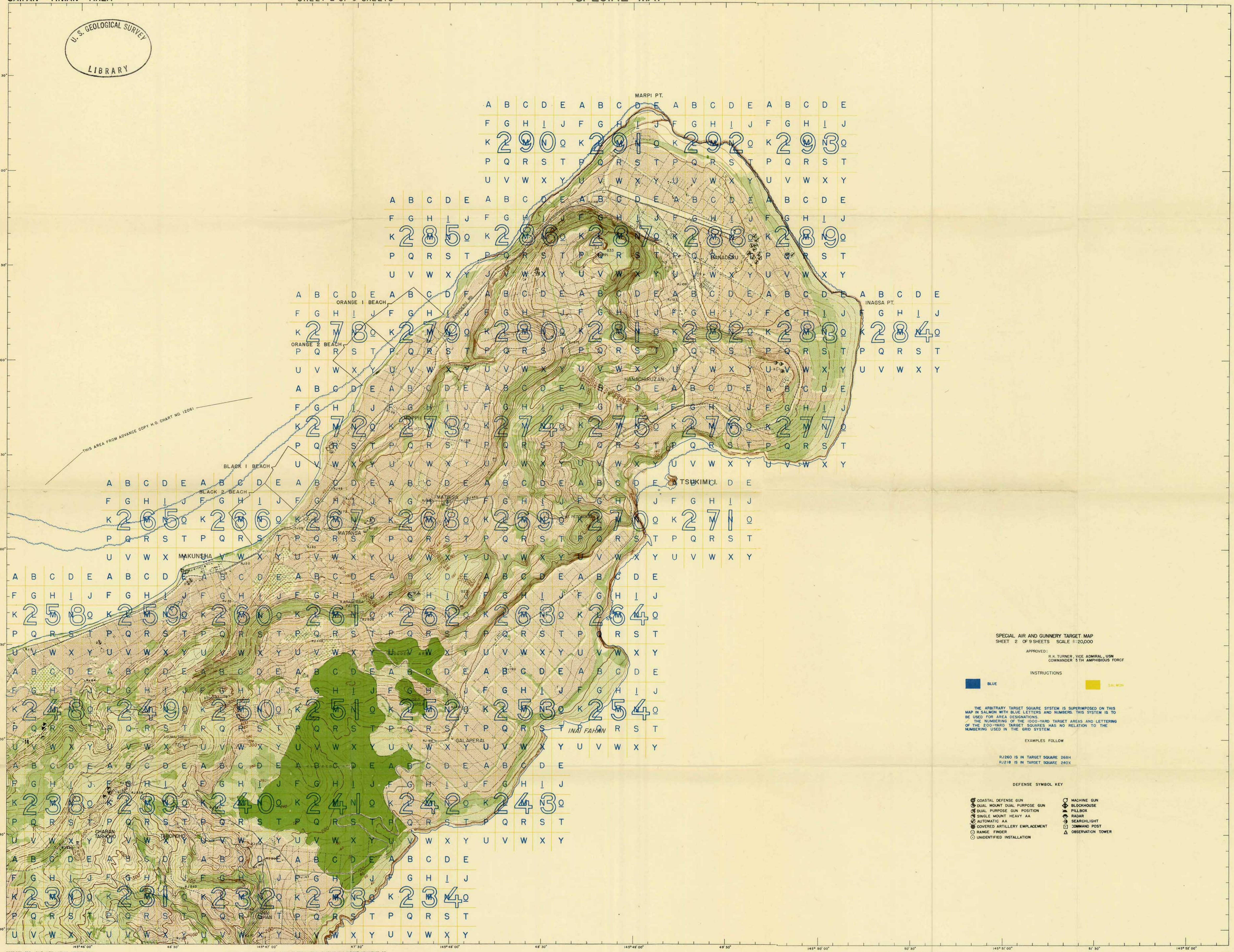
LEGEND

COCONUTS
LIGHT VEGETATION
HEAVY VEGETATION
CULTIVATED FIELDS
ROCKY BLUFFS
SAND BAR
VEGETATION (TYPE UNDETERMINED)
TELEPHONE OR POWER LINE

SPECIAL MAP

ADVANCE COPY

RESTRICTED



PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE COPY H.O. CHART NO. 12061 AND USMC MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC REPORT NO 387, APRIL 18, 1944
64TH ENGR. TOP BN. USAFICPA NO. 194-2

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF GROUND CONTROL OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE ARE NOT ACCURATELY DETERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POSSIBLE FROM AVAILABLE SOURCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.

SCALE 1:20,000

1000 500 0 1000 2000 3000 YDS.

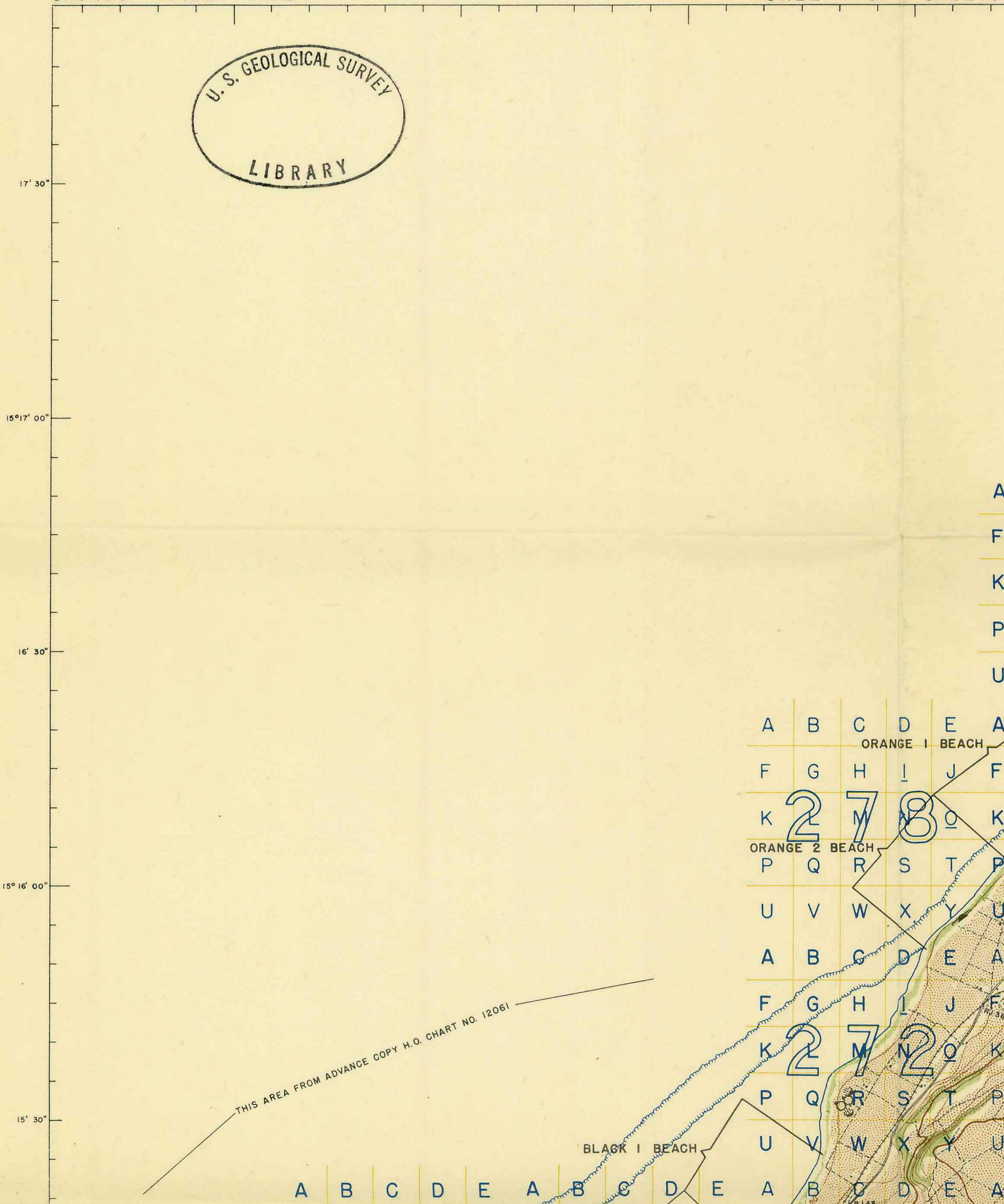
POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID

NOTE: CONTOURS BY 29TH ENGR TOPO BN, APRIL 1944 UTILIZING MULTIPLEX AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY ADJUSTED TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

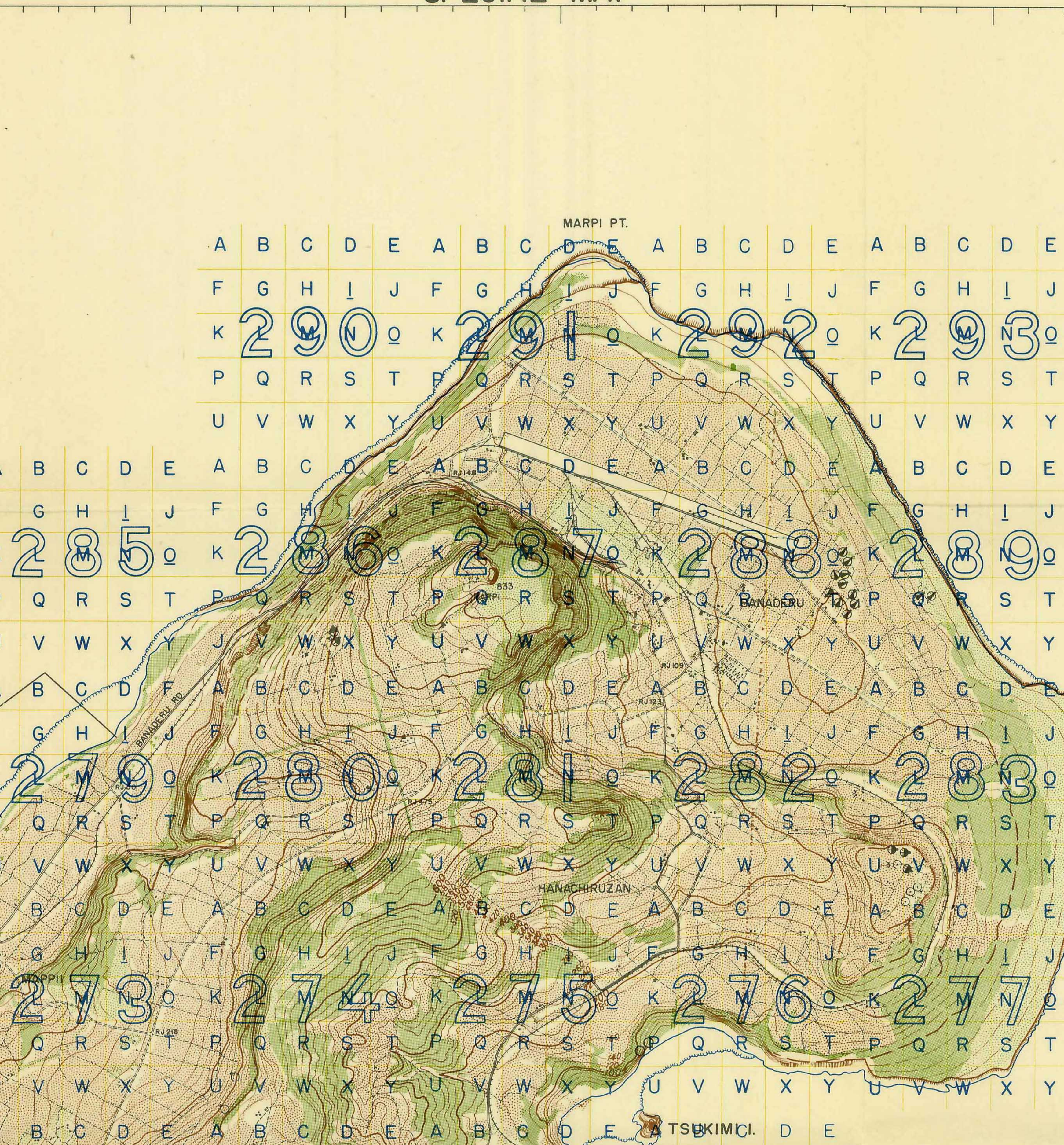
LEGEND

COASTAL... COCONUTS
LIGHT VEGETATION
HEAVY VEGETATION
CULTIVATED FIELDS
ROCKY BLUFFS
SAND BAR
VEGETATION (TYPE UNDETERMINED)
TELEPHONE OR POWER LINES

SAIPAN – TINIAN AREA



SPECIAL MAP


MARPI PT.
290
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293
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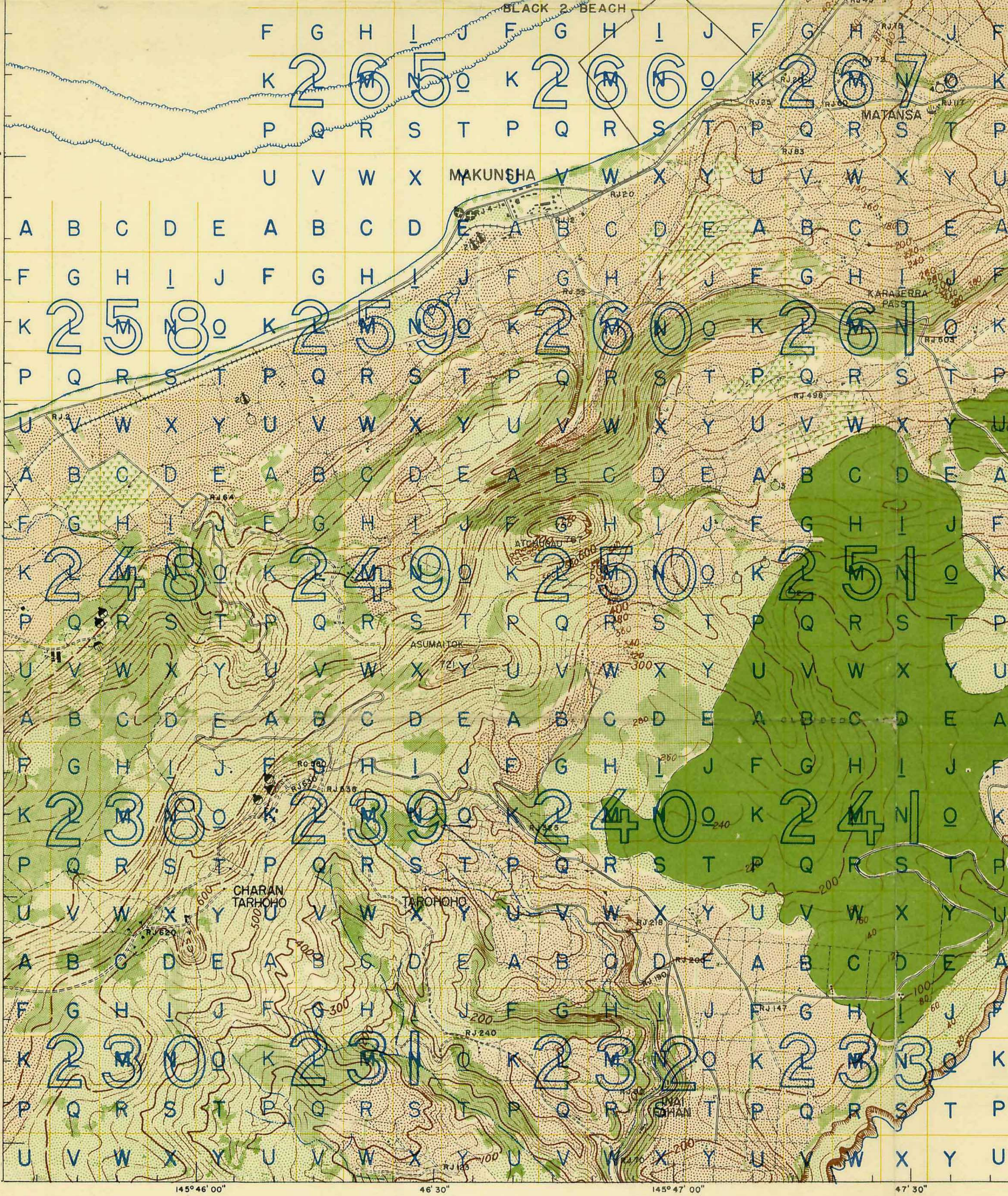
287
288
289
BANADERU
MARPI
BANADERU RD.
279
280
281
282
283
HANACHIRUZAN
273
274
275
276
277
TSUKIMI CI.

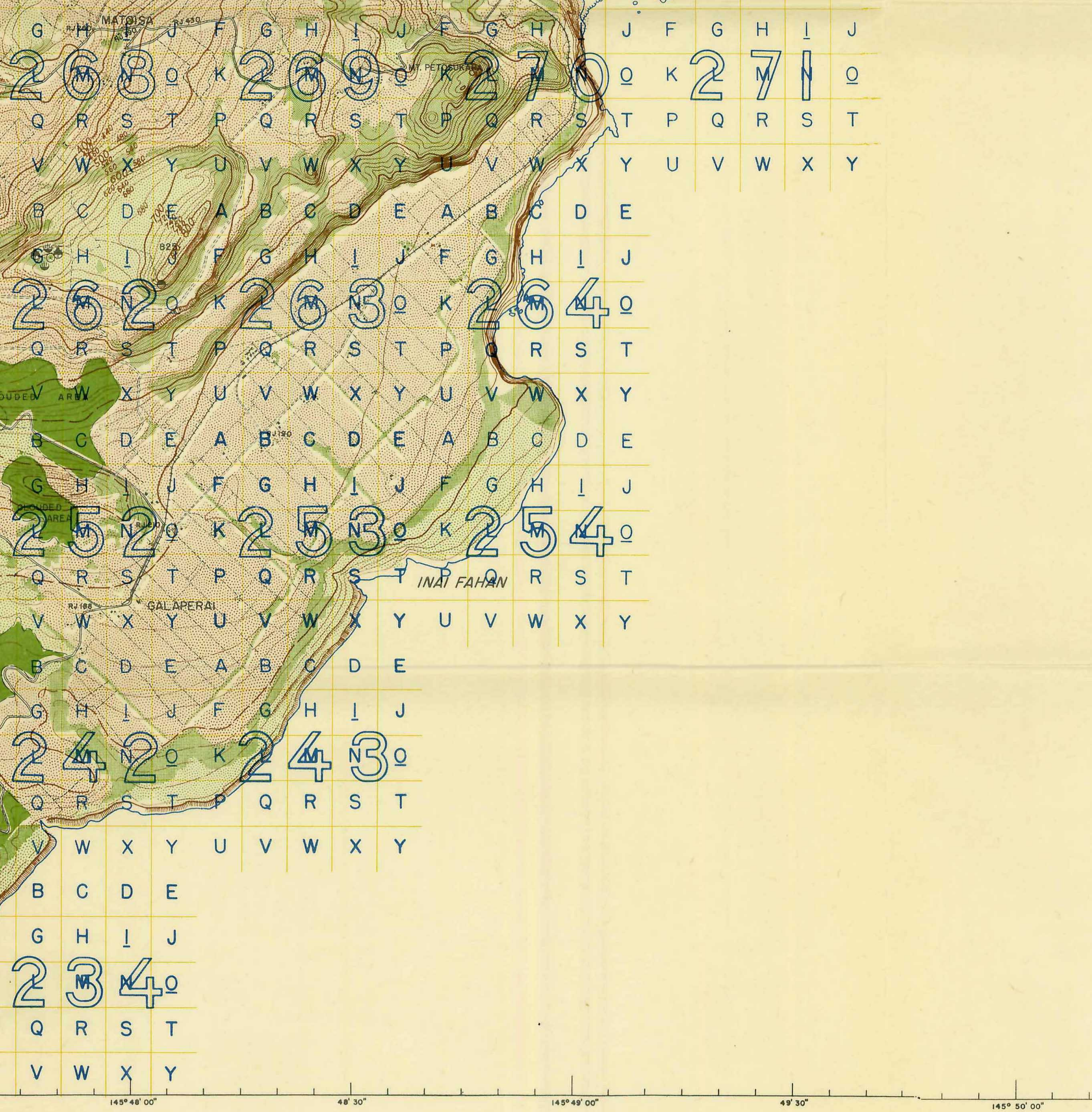

A B C D E
INAGSA PT.
F G H I J
K L M N O
P Q R S T
U V W X Y
284



PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
COPY H.O. CHART NO. 12061 AND U.S.M.C. MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
REPORT NO 387, APRIL 18, 1944
64TH ENGR. TOP. BN. USAFICPA NO. 194-2

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF GROUND CONTROL OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE ARE NOT ACCURATELY DETERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POSSIBLE FROM AVAILABLE SOURCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.



SCALE 1:20,000

1000 500 0 1000 2000 3000 YDS.

POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID

SPECIAL AIR AND GUNNERY TARGET MAP
SHEET 2 OF 9 SHEETS SCALE 1:20,000

APPROVED:

R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5TH AMPHIBIOUS FORCE

INSTRUCTIONS

BLUE

SALMON

THE ARBITRARY TARGET SQUARE SYSTEM IS SUPERIMPOSED ON THIS MAP IN SALMON WITH BLUE LETTERS AND NUMBERS. THIS SYSTEM IS TO BE USED FOR AREA DESIGNATIONS.

THE NUMBERING OF THE 1000-YARD TARGET AREAS AND LETTERING OF THE 200-YARD TARGET SQUARES HAS NO RELATION TO THE NUMBERING USED IN THE GRID SYSTEM.

EXAMPLES FOLLOW

RJ260 IS IN TARGET SQUARE 268H
RJ218 IS IN TARGET SQUARE 240X

DEFENSE SYMBOL KEY

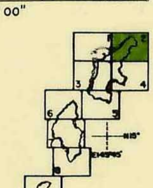
- COASTAL DEFENSE GUN
- DUAL MOUNT DUAL PURPOSE GUN
- DUAL PURPOSE GUN POSITION
- SINGLE MOUNT HEAVY AA
- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GUN
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

50' 30" 145° 51' 00" 51' 30" 145° 52' 00"

NOTE CONTOURS BY 29TH ENGR TOPO BN, APRIL 1944 UTILIZING MULTIPLEX AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY ADJUSTED TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

LEGEND

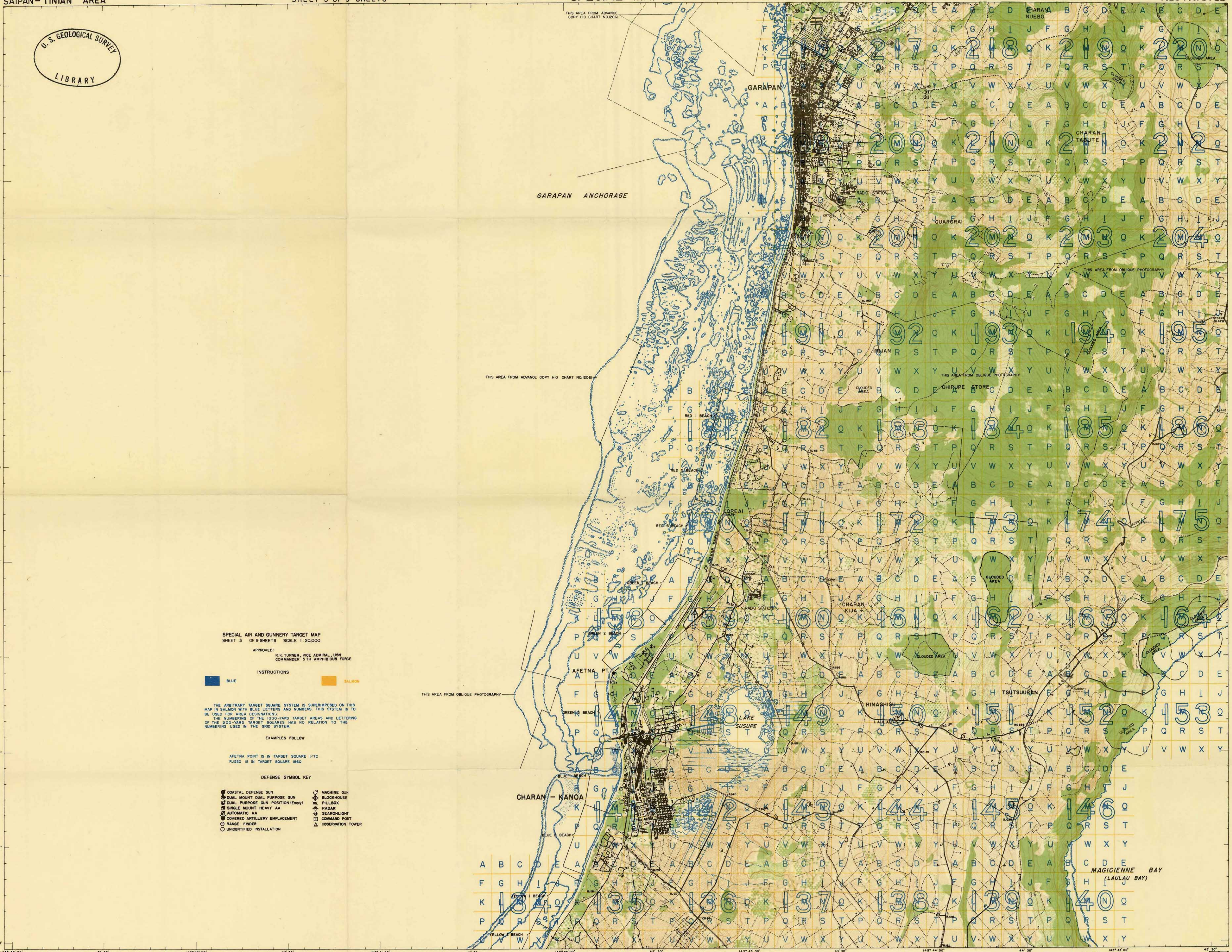
COCONUTS
LIGHT VEGETATION
HEAVY VEGETATION
CULTIVATED FIELDS
ROCKY BLUFFS
SAND BAR
VEGETATION (TYPE UNDETERMINED)
TELEPHONE OR POWER LINES



SPECIAL MAP

ADVANCE COPY

RESTRICTED



PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
COPY H.O. CHART NO. 12061 AND USMC MAP JAN 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
REPORT NO. 387, APRIL 18, 1944
64TH ENGR. TOP. BN. USAFICPA NO. 194-3

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF GROUND CONTROL OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE ARE NOT ACCURATELY DETERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POSSIBLE FROM AVAILABLE SOURCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.

SCALE 1:20,000

1000 500 0 1000 2000 3000 YDS.

POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID

LEGEND

COCONUTS
LIGHT VEGETATION
HEAVY VEGETATION
CULTIVATED FIELDS
ROCKY BLUFFS
SAND BAR
VEGETATION (TYPE UNDETERMINED)
TELEPHONE OR POWER LINES

SAIPAN-TINIAN AREA

12' 30"

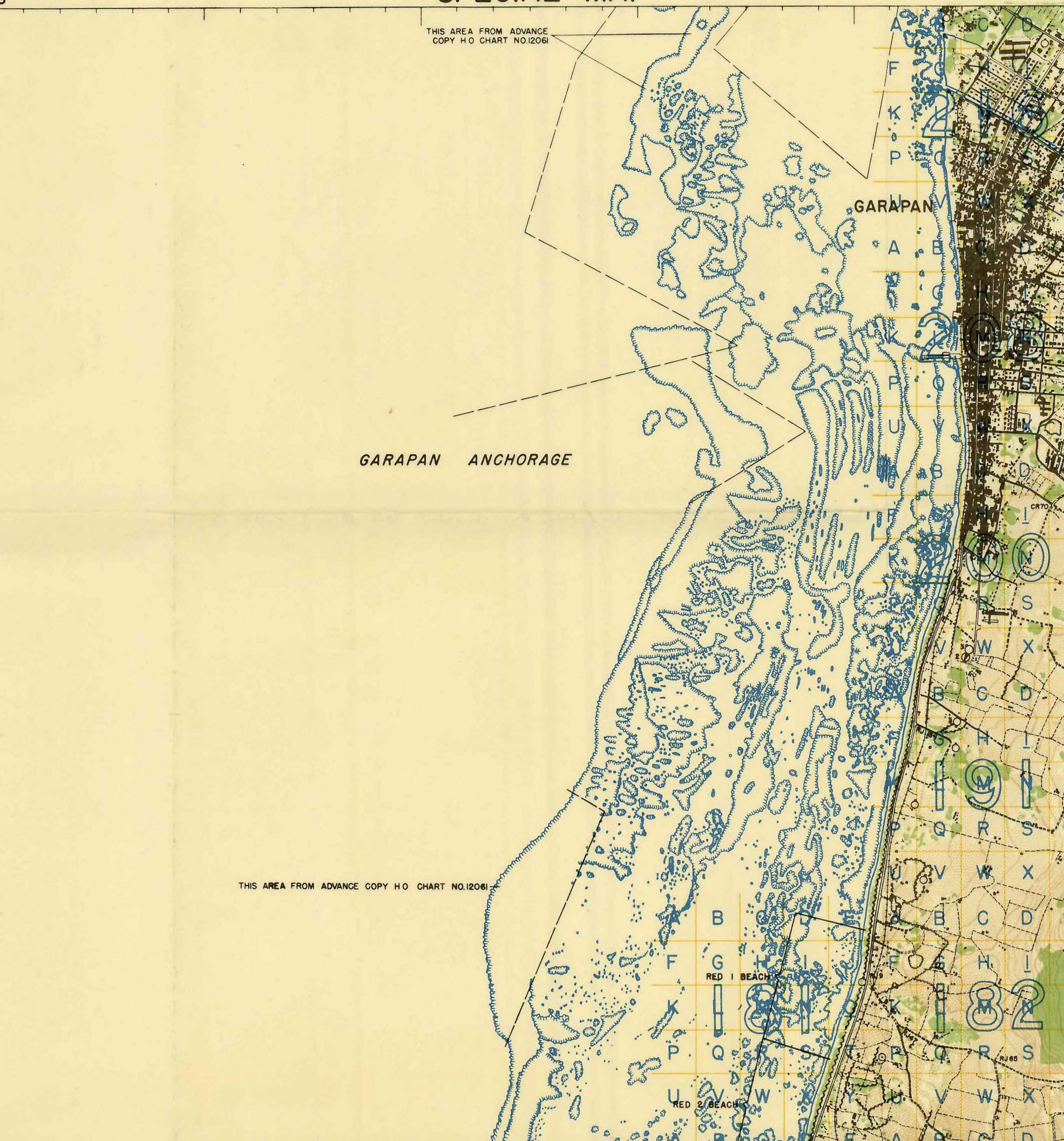
15° 12' 00"

11' 30"

15° 11' 00"

10' 30"

SPECIAL MAP


THIS AREA FROM ADVANCE COPY H O CHART NO.12061
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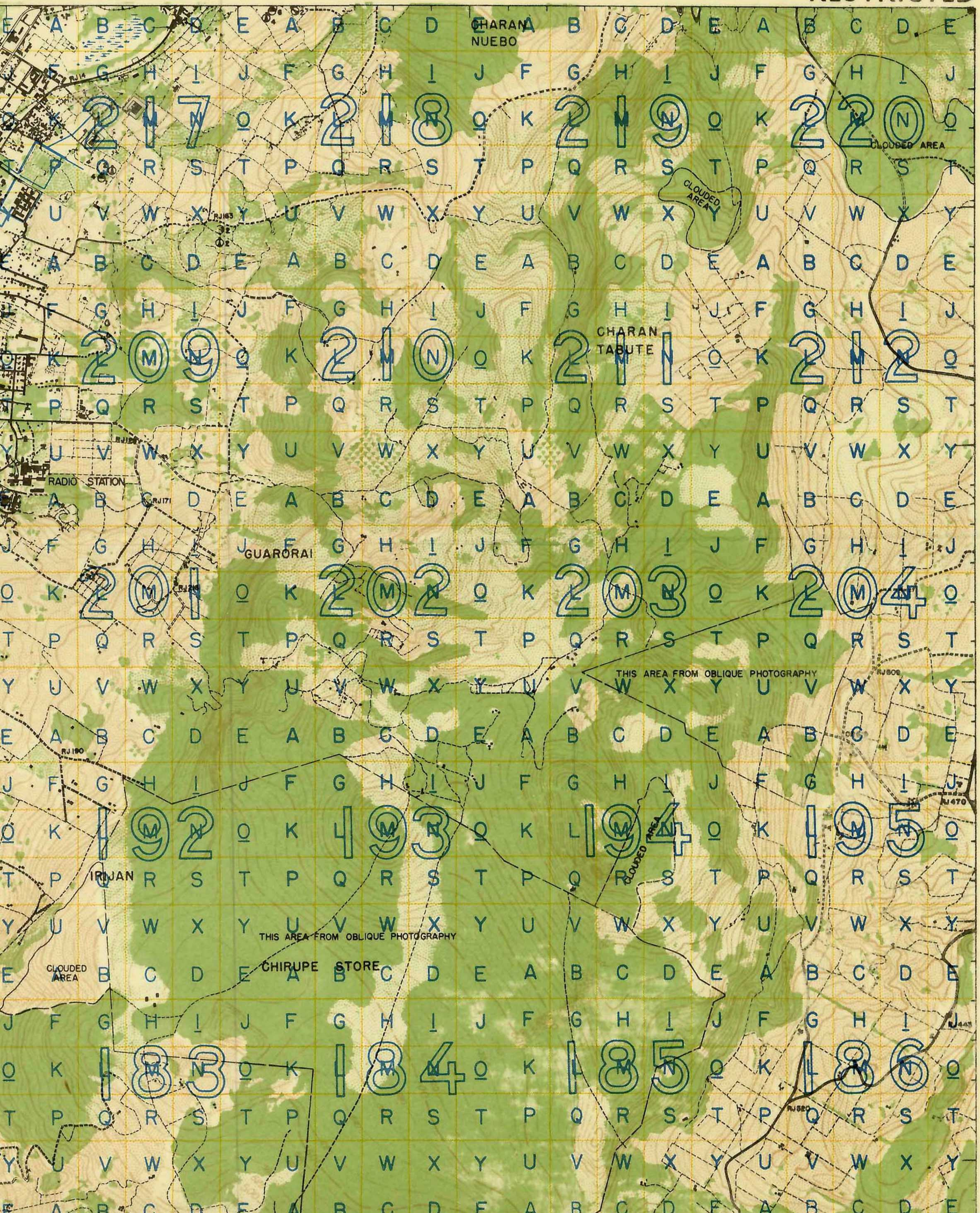
RED 1 BEACH
RED 2 BEACH

DVANCE COPY

RESTRICTED



15° 10' 00"

09' 30"

15° 09' 00"

08' 30"

15° 08' 00"

145° 39' 00" 39' 30" 145° 40' 00" 40' 30" 145° 41'

SPECIAL AIR AND GUNNERY TARGET MAP

SHEET 3 OF 9 SHEETS SCALE 1:20,000

APPROVED:

R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5 TH AMPHIBIOUS FORCE

INSTRUCTIONS

BLUE

SALMON

THE ARBITRARY TARGET SQUARE SYSTEM IS SUPERIMPOSED ON THIS MAP IN SALMON WITH BLUE LETTERS AND NUMBERS. THIS SYSTEM IS TO BE USED FOR AREA DESIGNATIONS.

THE NUMBERING OF THE 1000-YARD TARGET AREAS AND LETTERING OF THE 200-YARD TARGET SQUARES HAS NO RELATION TO THE NUMBERING USED IN THE GRID SYSTEM.

EXAMPLES FOLLOW

AFETNA POINT IS IN TARGET SQUARE 1-7C
RJ520 IS IN TARGET SQUARE 186Q

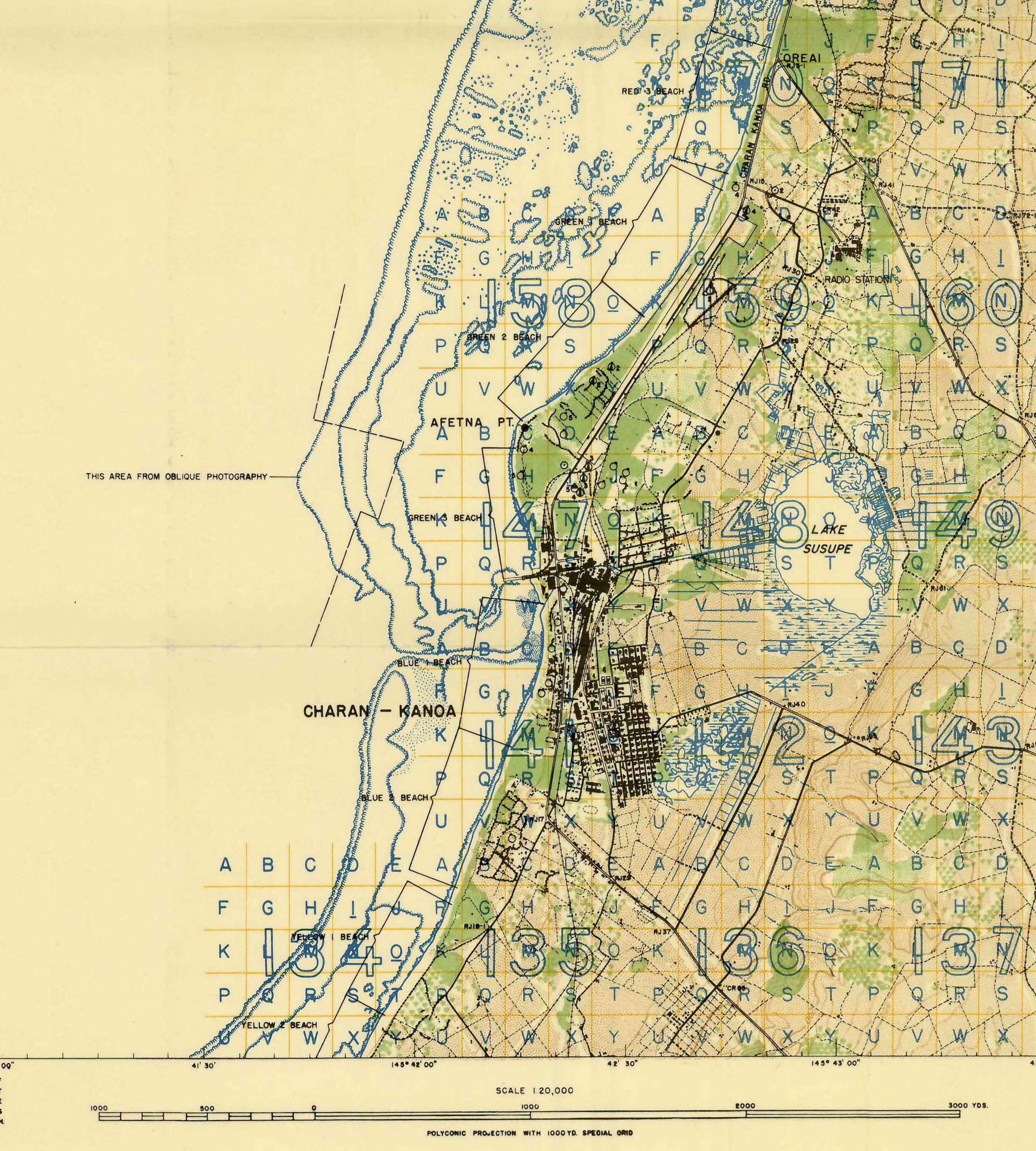
DEFENSE SYMBOL KEY

- COASTAL DEFENSE GUN
- DUAL MOUNT DUAL PURPOSE GUN
- DUAL PURPOSE GUN POSITION (Empty)
- SINGLE MOUNT HEAVY AA
- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GUN
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64 TH ENGR TOP BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
COPY H.O. CHART NO. 12061 AND USMC MAP JAN 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
REPORT NO 387, APRIL 18, 1944
64 TH ENGR TOP BN. USAFICPA NO 194-3

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF GROUND CONTROL OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE ARE NOT ACCURATELY DETERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POSSIBLE FROM AVAILABLE SOURCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.



RED 3 BEACH
OREAI
CHARAN KANOA RD.
GREEN 1 BEACH
RADIO STATION
GREEN 2 BEACH
AFETNA PT.
THIS AREA FROM OBLIQUE PHOTOGRAPHY
GREEN 3 BEACH
LAKE SUSUPE
BLUE 1 BEACH
CHARAN - KANOA
BLUE 2 BEACH
YELLOW 1 BEACH
YELLOW 2 BEACH
41' 30"
145° 42' 00"
42' 30"
145° 43' 00"
SCALE 1:20,000
1000
500
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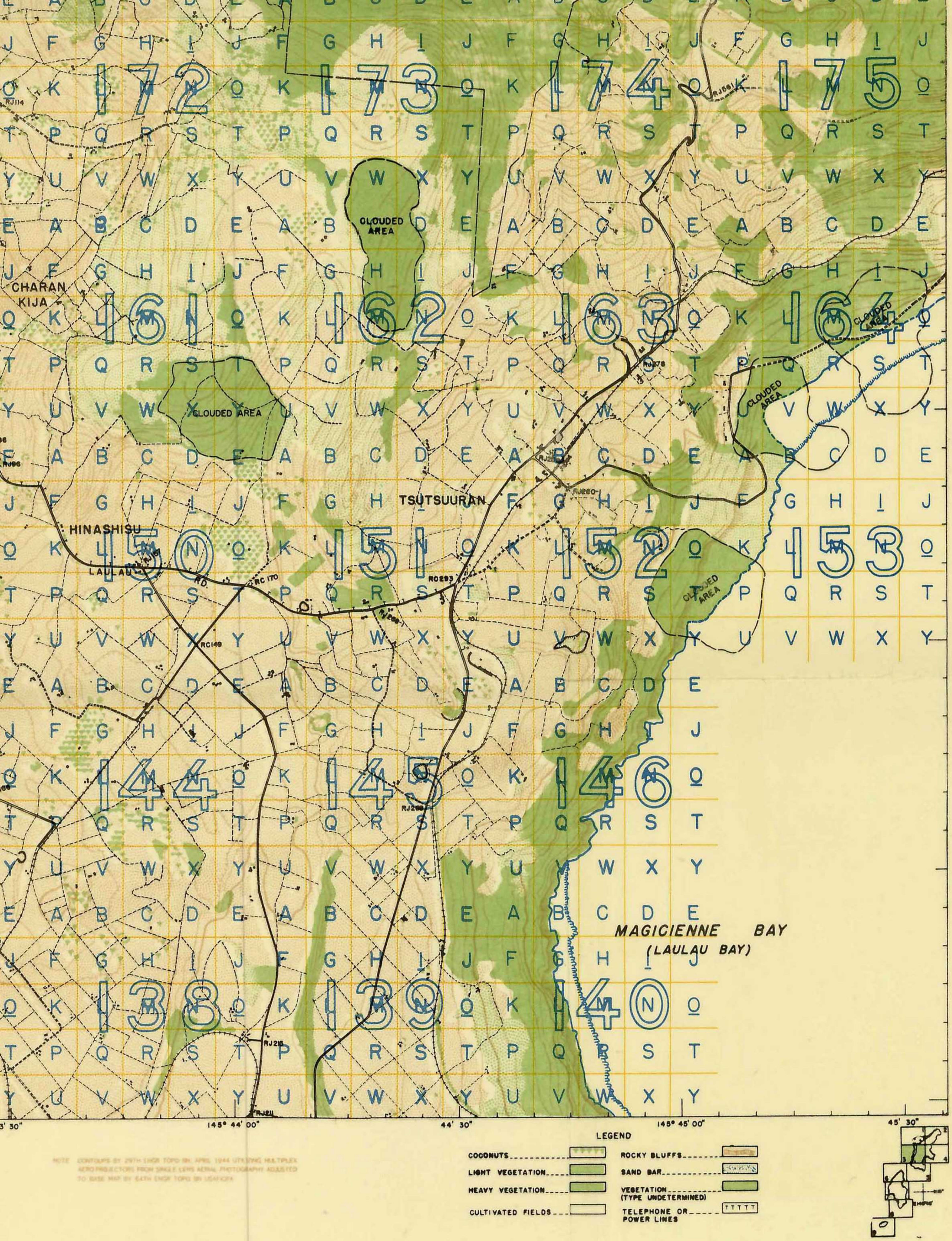
1000
2000
3000 YDS.
POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID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144
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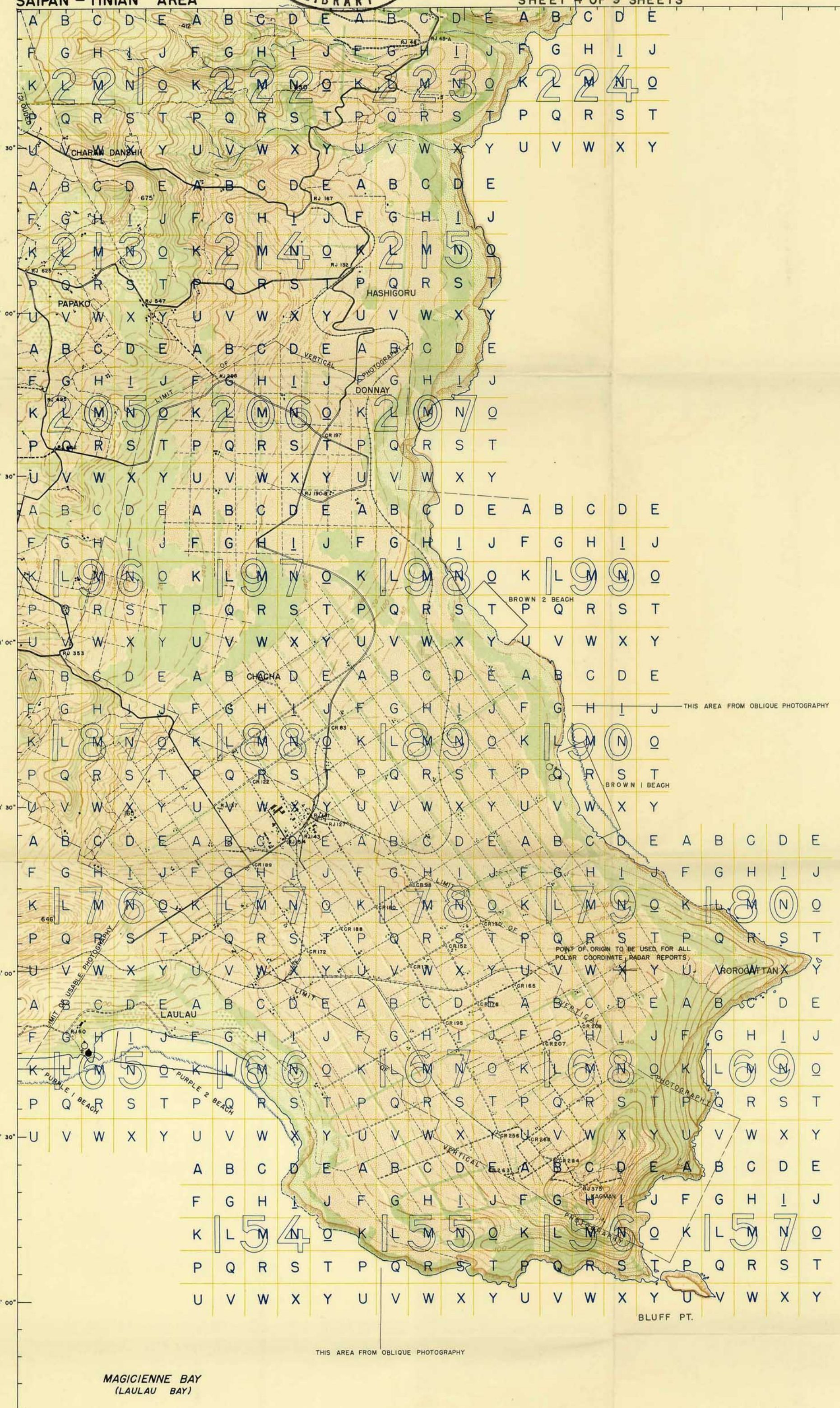
138
139
140
CHARAN KIJA
HINASHISU
LAULAU
TSUTSUURAN
CLOUDED AREA
MAGICIENNE BAY
(LAULAU BAY)
145° 44' 00"
44' 30"
145° 45' 00"
45' 30"
LEGEND
COCONUTS
LIGHT VEGETATION
HEAVY VEGETATION
CULTIVATED FIELDS
ROCKY BLUFFS
SAND BAR
VEGETATION (TYPE UNDETERMINED)
TELEPHONE OR POWER LINES
NOTE: CONTOURS BY 29TH ENGR TOPO BN, APRIL 1944 UTILIZING MULTIPLEX AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY ADJUSTED TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

SPECIAL MAP

ADVANCE COPY

RESTRICTED



SPECIAL AIR AND GUNNERY TARGET MAP
SHEET 4 OF 9 SHEETS SCALE 1:20,000

APPROVED:
R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5 TH AMPHIBIOUS FORCE

INSTRUCTIONS

BLUE SALMON

THE ARBITRARY TARGET SQUARE SYSTEM IS SUPERIMPOSED ON THIS MAP IN SALMON WITH BLUE LETTERS AND NUMBERS. THIS SYSTEM IS TO BE USED FOR AREA DESIGNATIONS.

THE NUMBERING OF THE 1000-YARD TARGET AREAS AND LETTERING OF THE 200-YARD TARGET SQUARES HAS NO RELATION TO THE NUMBERING USED IN THE GRID SYSTEM.

EXAMPLES FOLLOW

BLUFF POINT IS IN TARGET SQUARE 156T
RJ482 IS IN TARGET SQUARE 205Q

DEFENSE SYMBOL KEY

- COASTAL DEFENSE GUN
- DUAL MOUNT DUAL PURPOSE GUN
- DUAL PURPOSE GUN POSITION (Empty)
- SINGLE MOUNT HEAVY AA
- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GUN
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A. BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE COPY H.O. CHART NO. 12061 AND USMC MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC REPORT NO. 387, APRIL 18, 1944
64TH ENGR. TOP. BN. NO. 194-4

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM VERTICAL AND OBLIQUE PHOTOGRAPHS (COVERAGE INCOMPLETE) USING ADVANCE COPY H.O. CHART NO. 12061 FOR BASIC CONTROL. AZIMUTH AND SCALE, ALTHOUGH APPROXIMATE, ARE REPRESENTED AS ACCURATELY AS POSSIBLE. CORRECTION AND OTHER COMMENTS SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.

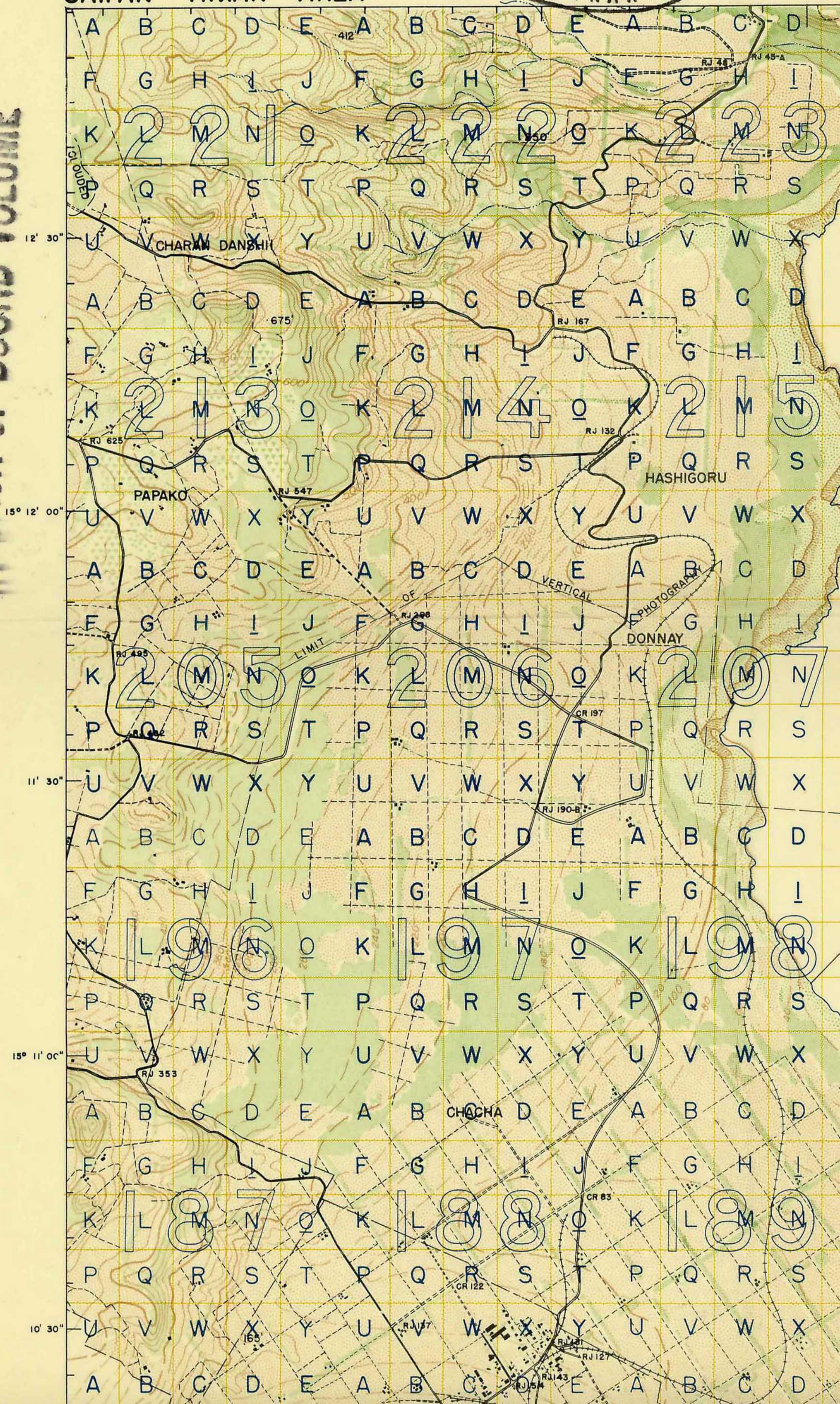
SCALE 1:20000
1000 500 0 1000 2000 3000 YDS.
POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID

NOTE: CONTOURS BY 29TH ENGR TOPO BN. APRIL 1944 UTILIZING MULTIPLEX AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY ADJUSTED TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

LEGEND

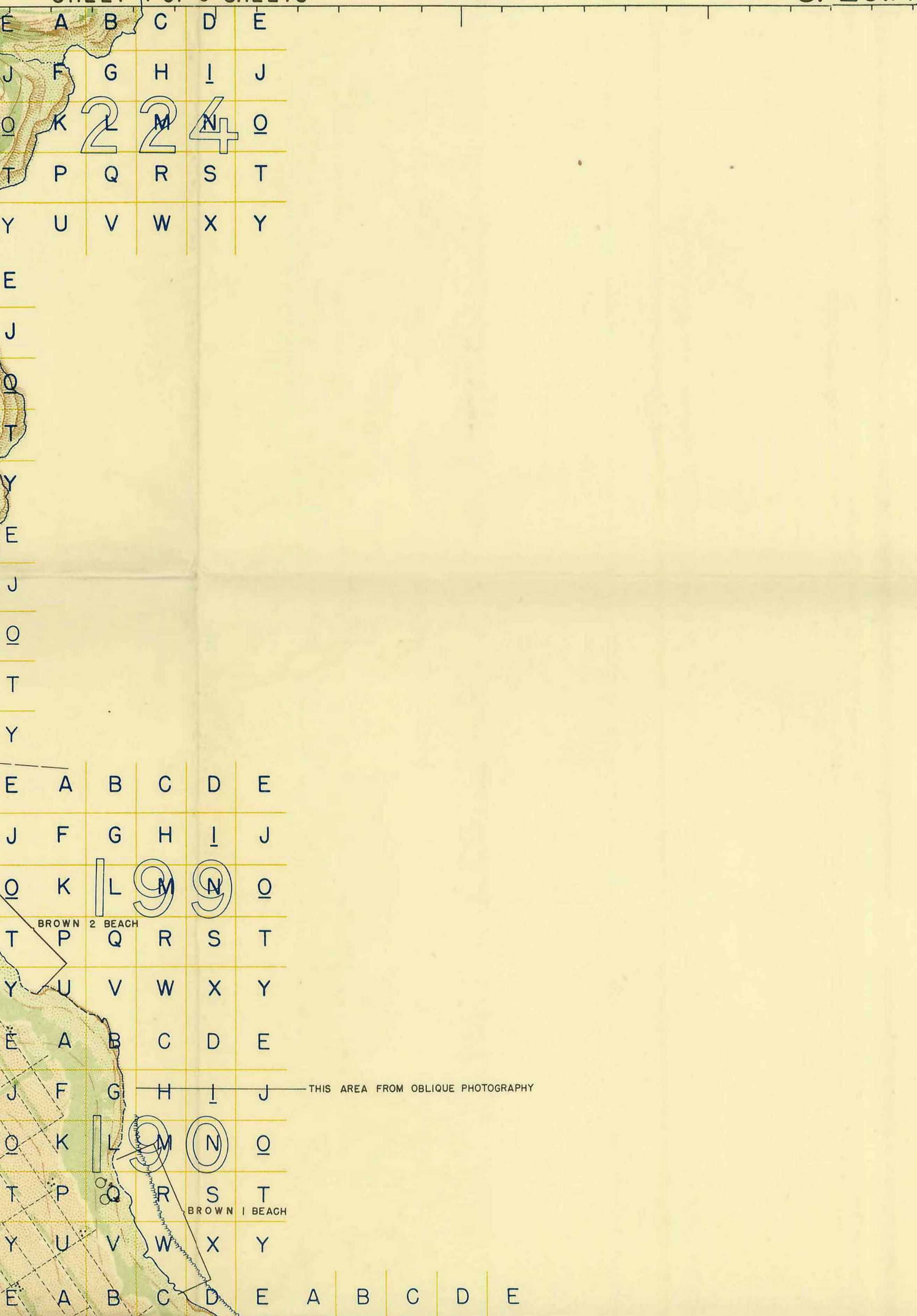
COCONUTS	ROCKY BLUFFS
LIGHT VEGETATION	SAND BAR
HEAVY VEGETATION	VEGETATION (TYPE UNDETERMINED)
CULTIVATED FIELDS	TELEPHONE OR POWER LINE

SAIPAN – TINIAN AREA



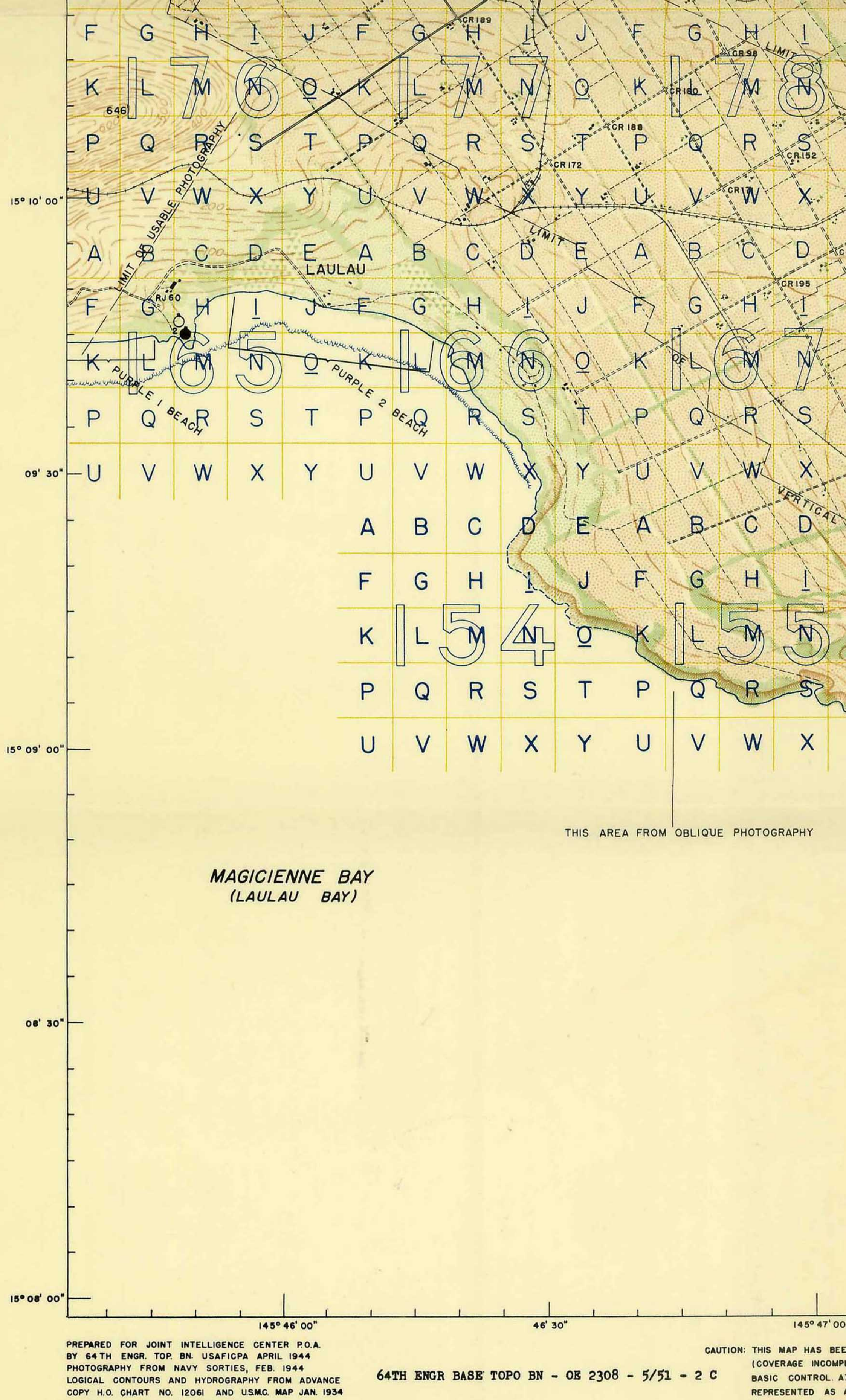
SHEET 4 OF 9 SHEETS

SPECIA



L MAP

ADVANCE COPY



PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
COPY H.O. CHART NO. 12061 AND U.S.M.C. MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
REPORT NO. 387, APRIL 18, 1944
64TH ENGR. TOP. BN. NO. 194-4

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEE
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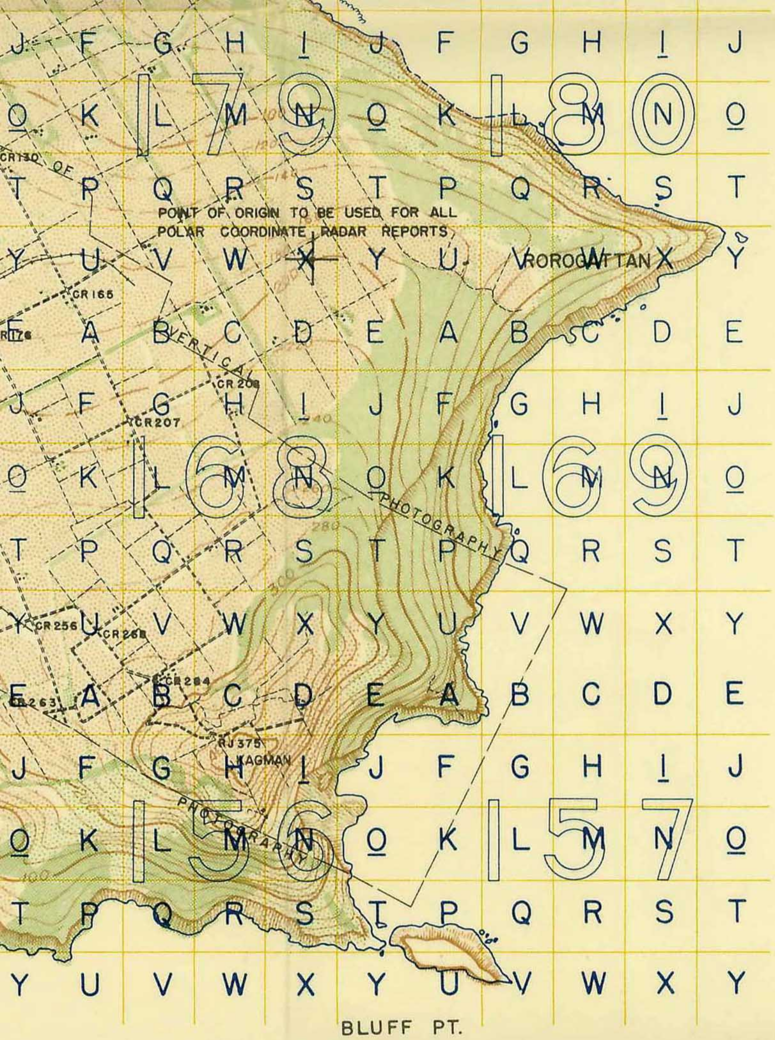
BASIC CONTROL. A
REPRESENTED AS
COMMENTS SHOULD
OCEAN AREAS, P.H.



47' 30"   145° 48' 00"   48' 30"

N COMPILED FROM VERTICAL AND OBLIQUE PHOTOGRAPHS
LETE) USING ADVANCE COPY H.O. CHART NO. 12061 FOR
ZIMUTH AND SCALE, ALTHOUGH APPROXIMATE, ARE
ACCURATELY AS POSSIBLE. CORRECTION AND OTHER
BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC

SCALE I

1000 500 0 10

POLYCONIC PROJECTION W

145° 49' 00 | 49' 30" | 145° 50' 00" | 50' 30"

:20000

00 | 2000 | 3000 YDS.

ITH 1000 YD. SPECIAL GRID

NOTE CONTOURS BY 29TH ENGR TOPO BN APRIL 1944 UTILIZING MULTIPLE
AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY ADJUSTE
TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

SPECIAL AIR AND GUNNERY TARGET MAP

SHEET 4 OF 9 SHEETS SCALE 1:20,000

APPROVED:

R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5 TH AMPHIBIOUS FORCE

INSTRUCTIONS

BLUE

SALMON

THE ARBITRARY TARGET SQUARE SYSTEM IS SUPERIMPOSED ON THIS MAP IN SALMON WITH BLUE LETTERS AND NUMBERS. THIS SYSTEM IS TO BE USED FOR AREA DESIGNATIONS.

THE NUMBERING OF THE 1000-YARD TARGET AREAS AND LETTERING OF THE 200-YARD TARGET SQUARES HAS NO RELATION TO THE NUMBERING USED IN THE GRID SYSTEM.

EXAMPLES FOLLOW

BLUFF POINT IS IN TARGET SQUARE 156T

RJ482 IS IN TARGET SQUARE 205Q

DEFENSE SYMBOL KEY

- COASTAL DEFENSE GUN
- DUAL MOUNT DUAL PURPOSE GUN
- DUAL PURPOSE GUN POSITION (Empty)
- SINGLE MOUNT HEAVY AA
- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GUN
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

145° 51' 00" 51' 30" 145° 52' 00"

LEGEND

COCONUTS

LIGHT VEGETATION

HEAVY VEGETATION

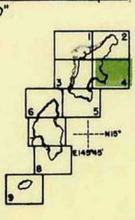
CULTIVATED FIELDS

ROCKY BLUFFS

SAND BAR

VEGETATION (TYPE UNDETERMINED)

TELEPHONE OR POWER LINE

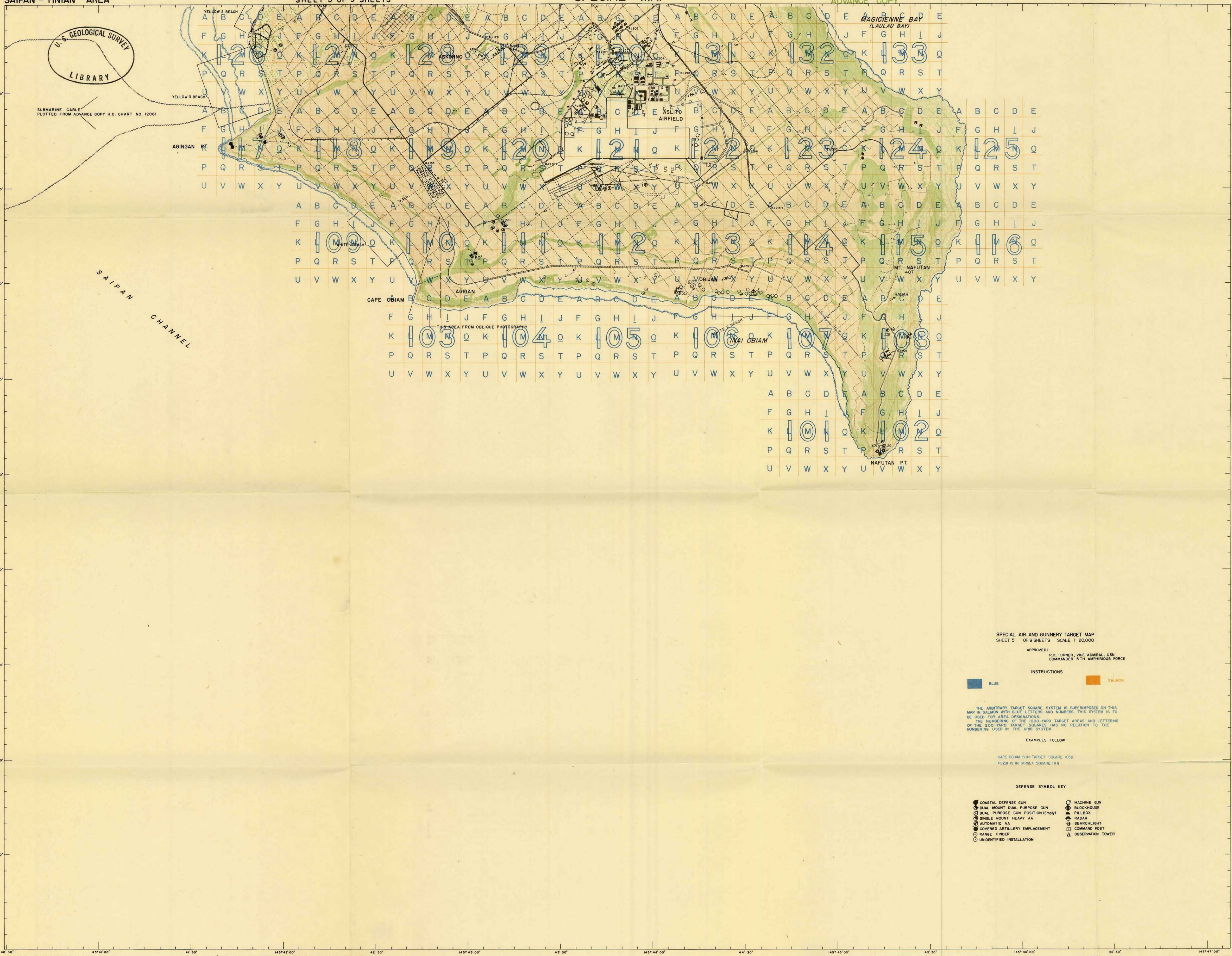


SAIPAN – TINIAN AREA SHEET 5 OF 9 SHEETS

SPECIAL MAP

ADVANCE COPY

RESTRICTED



40' 30" 145° 41' 00" 41' 30" 145° 42' 00" 42' 30" 145° 43' 00" 43' 30" 145° 44' 00" 44' 30" 145° 45' 00" 45' 30" 145° 46' 00" 46' 30" 145° 47' 00"

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
COPY H.O. CHART NO. 12061 AND U.S.M.C. MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
REPORT NO. 387, APRIL 18, 1944
64TH ENGR. TOP BN. USAFICPA NO. 194-5

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BEEN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF GROUND CONTROL OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE ARE NOT ACCURATELY DETERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POSSIBLE FROM AVAILABLE SOURCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS SHOULD BE FORWARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.

SCALE 1:20,000

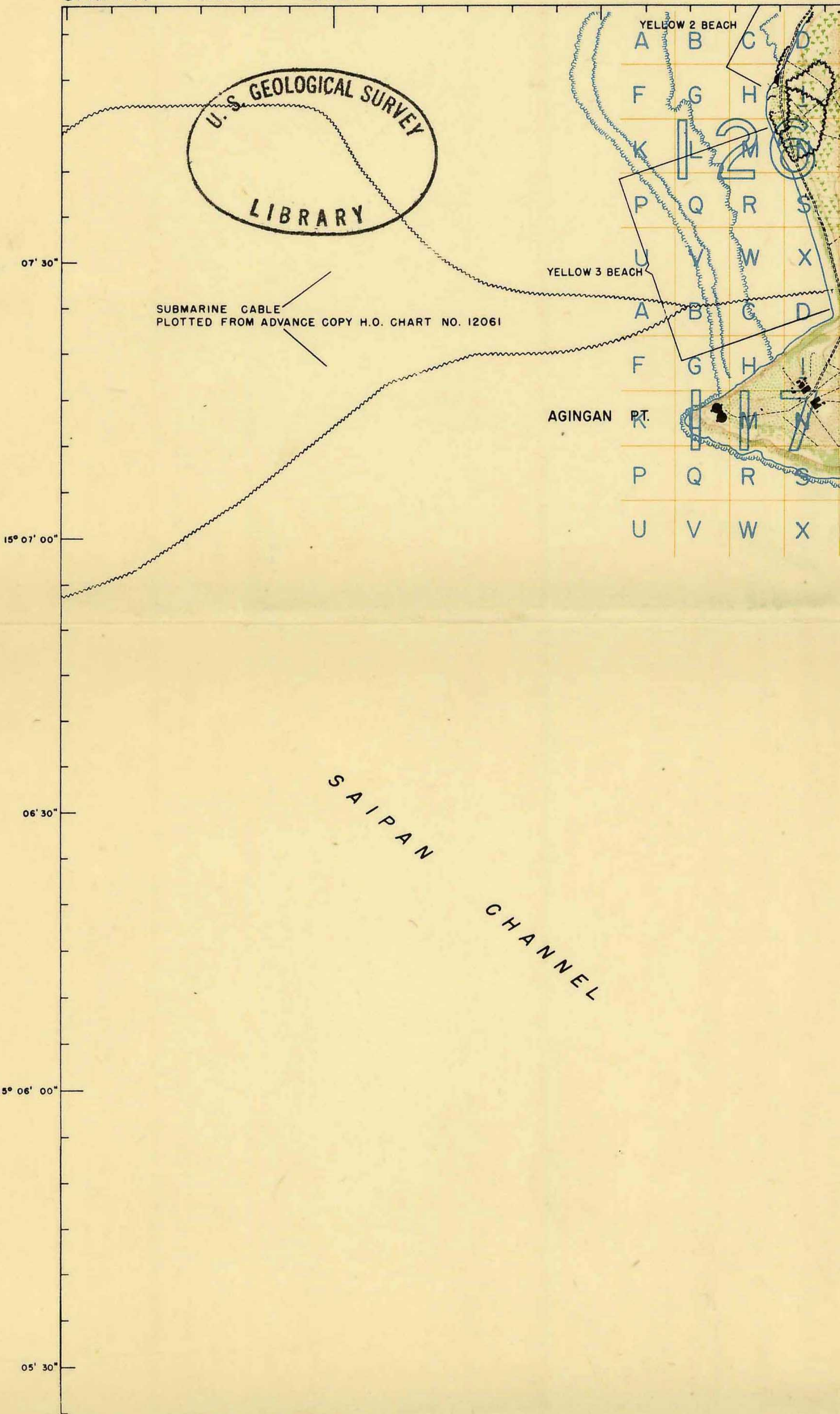
1000 500 0 1000 2000 3000 YDS.

POLYCONIC PROJECTION WITH 1000 YD. SPECIAL GRID

LEGEND

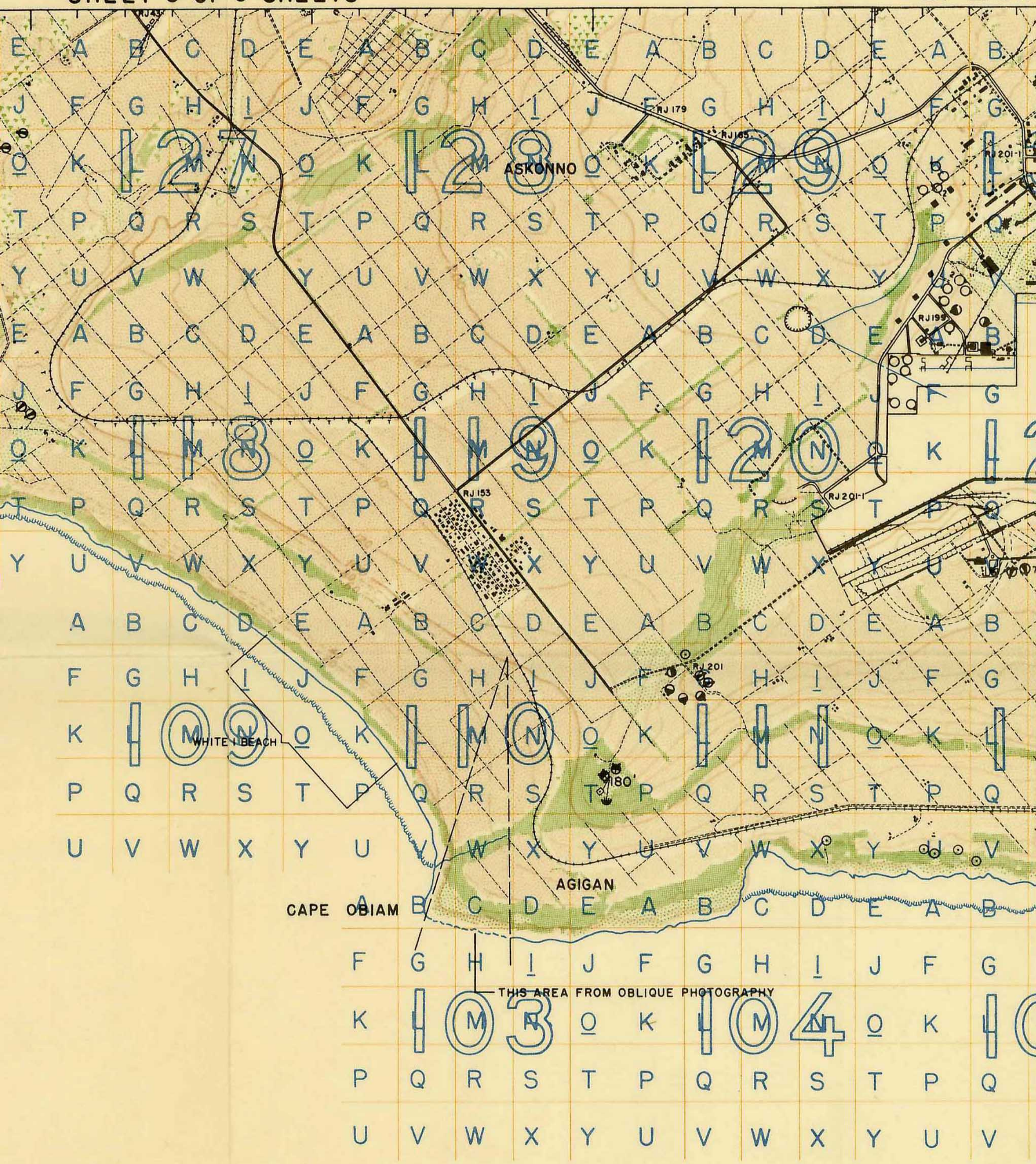
COCONUTS
LIGHT VEGETATION
HEAVY VEGETATION
CULTIVATED FIELDS
ROCKY BLUFFS
SAND BAR
VEGETATION (TYPE UNDETERMINED)
TELEPHONE OR POWER LINE

SAIPAN – TINIAN AREA



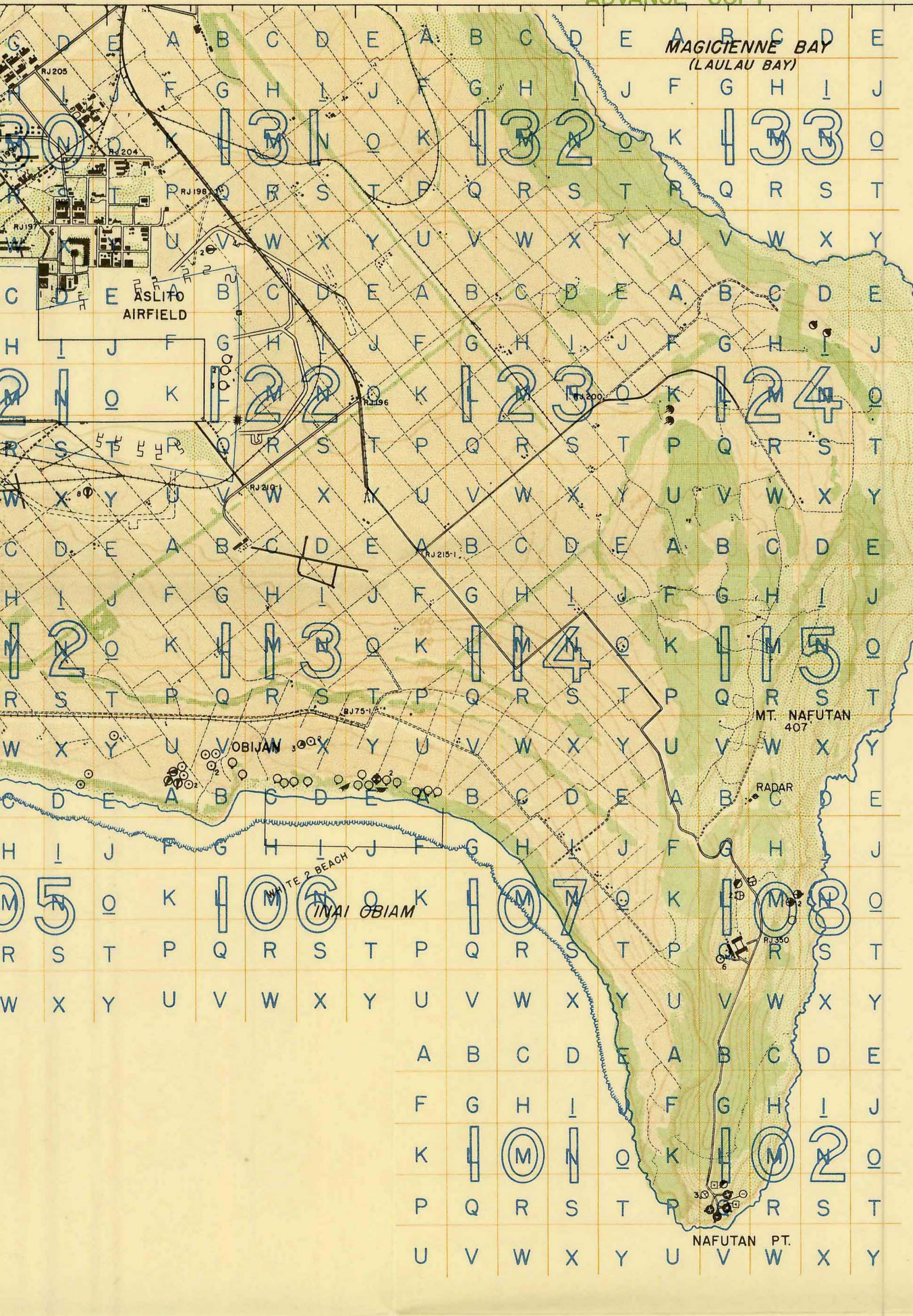
SHEET 5 OF 9 SHEETS

SPECIA

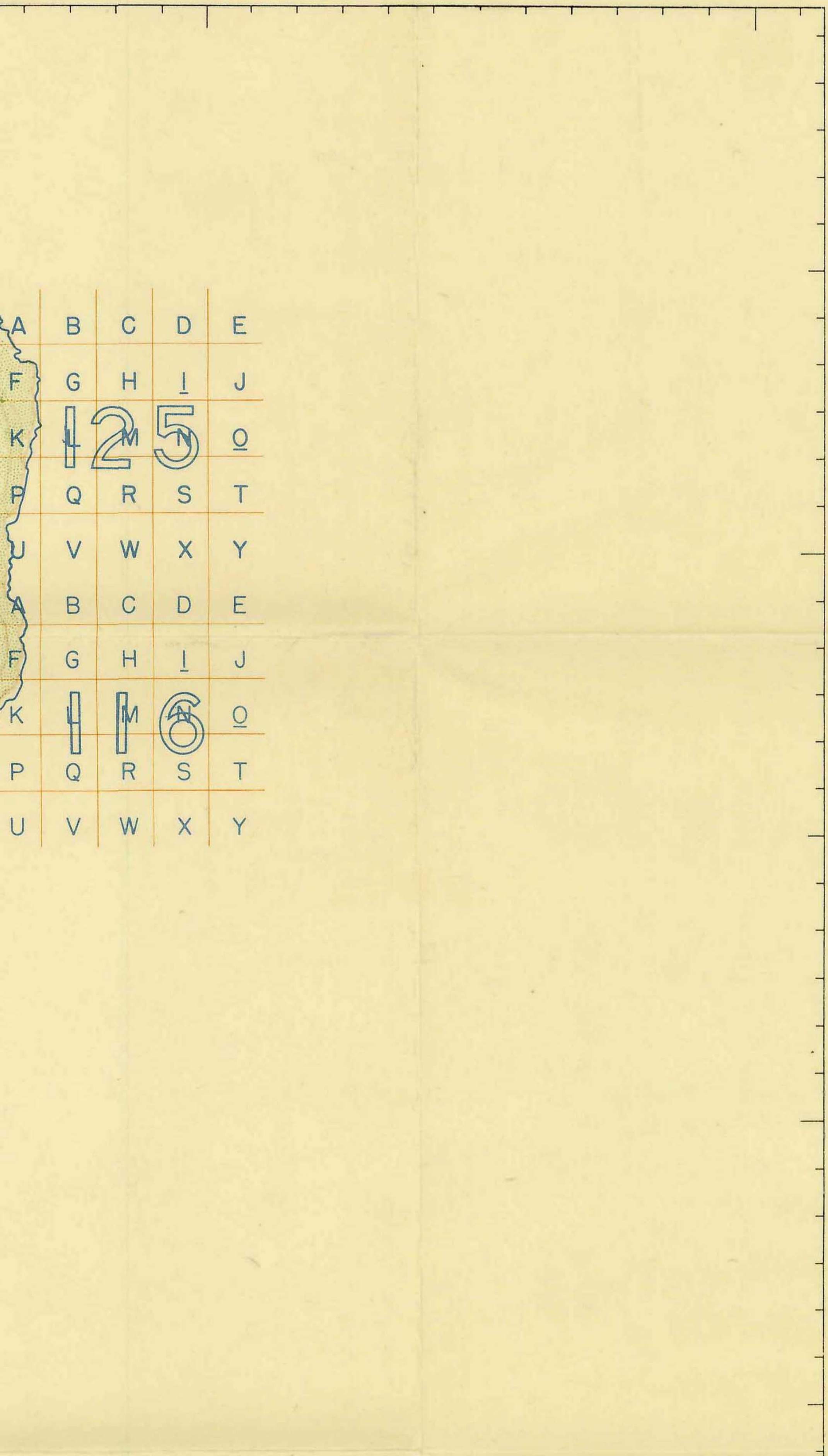


AL MAP

ADVANCE COPY



RESTRICTED


A B C D E
F G H I J
K L M N O
P Q R S T
U V W X Y
125
A B C D E
F G H I J
K L M N O
P Q R S T
U V W X Y
116

15°05' 00"

04' 30"

15° 04' 00"

03' 30"

40' 30" 45°41' 00" 41' 30"

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE
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REPORT NO. 387, APRIL 18, 1944
64TH ENGR. TOP BN. USAFICPA NO. 194-5

64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

CAUTION: THIS MAP HAS BE
GROUND CONTROL
ACCURATELY DETE
FROM AVAILABLE S
SHOULD BE FORWA

145° 42' 00"

42' 30"

145° 43' 00"

43' 30"

EN COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF
OR RECONNAISSANCE; THEREFORE AZIMUTH AND SCALE ARE NOT
ERMINED. THEY ARE REPRESENTED AS ACCURATELY AS POSSIBLE
SOURCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS
ARDED TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.

SCALE

1000 500 0

POLYCONIC PROJECTION

145° 44' 00"

44' 30"

145° 45' 00"

45' 30"

E 1:20,000

1000 2000 3000 YDS.

. WITH 1000 YD. SPECIAL GRID

NOTE: CONTOURS BY 29TH ENGR TOPO BN. APRIL 1944 UTILIZING M
AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY A
TO BASE MAP BY 64TH ENGR TOPO BN USAFISPA

SPECIAL AIR AND GUNNERY TARGET MAP

SHEET 5 OF 9 SHEETS SCALE 1:20,000

APPROVED:

R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5TH AMPHIBIOUS FORCE

INSTRUCTIONS

BLUE

SALMON

THE ARBITRARY TARGET SQUARE SYSTEM IS SUPERIMPOSED ON THIS MAP IN SALMON WITH BLUE LETTERS AND NUMBERS. THIS SYSTEM IS TO BE USED FOR AREA DESIGNATIONS.

THE NUMBERING OF THE 1000-YARD TARGET AREAS AND LETTERING OF THE 200-YARD TARGET SQUARES HAS NO RELATION TO THE NUMBERING USED IN THE GRID SYSTEM.

EXAMPLES FOLLOW

CAPE OBIAM IS IN TARGET SQUARE 103B

RJ201 IS IN TARGET SQUARE 111G

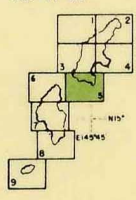
DEFENSE SYMBOL KEY

- COASTAL DEFENSE GUN
- DUAL MOUNT DUAL PURPOSE GUN
- DUAL PURPOSE GUN POSITION (Empty)
- SINGLE MOUNT HEAVY AA
- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GUN
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

145° 46' 00" 46' 30" 145° 47' 00"

LEGEND

- COCONUTS
- LIGHT VEGETATION
- HEAVY VEGETATION
- CULTIVATED FIELDS
- ROCKY BLUFFS
- SAND BAR
- VEGETATION (TYPE UNDETERMINED)
- TELEPHONE OR POWER LINE

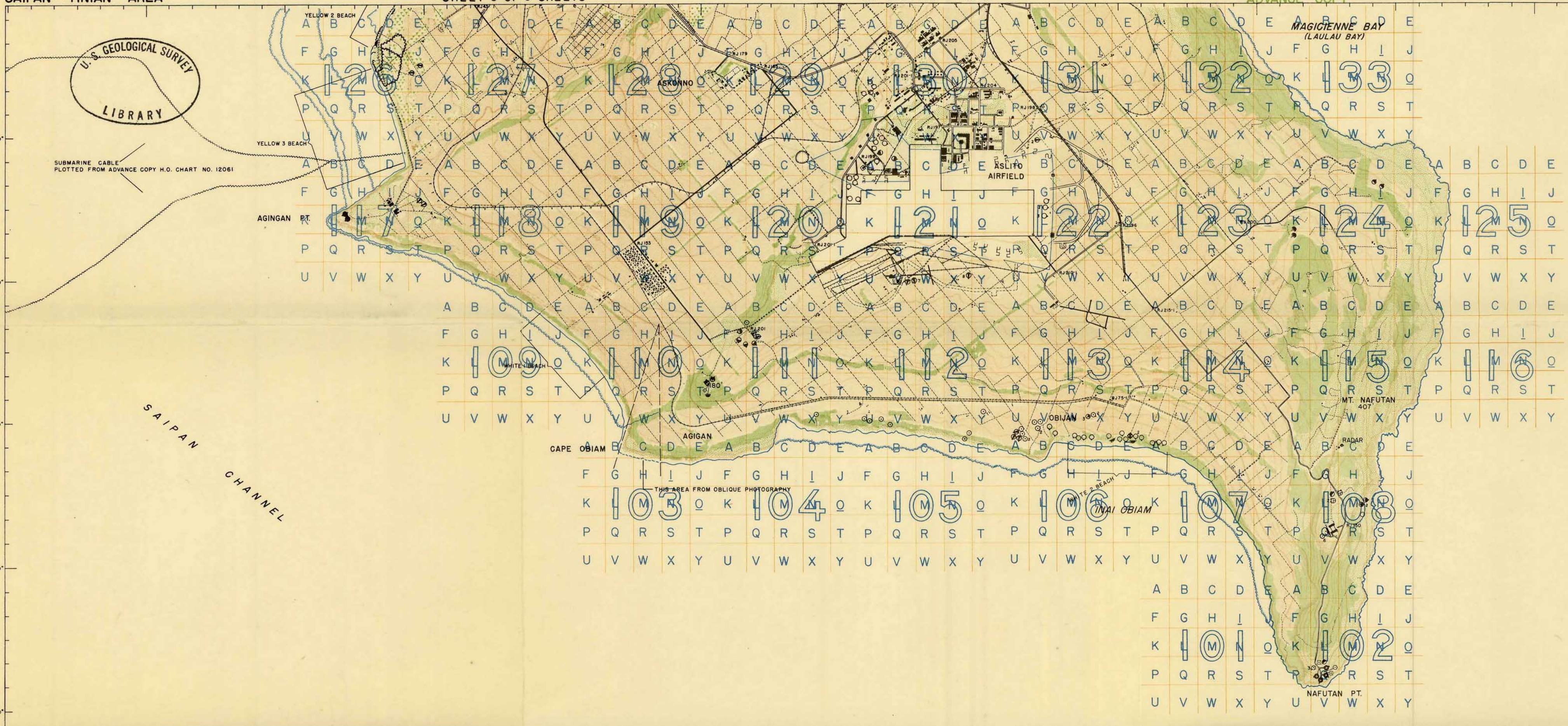


SAIPAN - TINIAN AREA SHEET 5 OF 9 SHEETS

SPECIAL MAP

ADVANCE COPY

RESTRICTED



SPECIAL AIR AND GUNNERY TARGET MAP
SHEET 5 OF 9 SHEETS SCALE 1:20,000

APPROVED:
R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5TH AMPHIBIOUS FORCE

INSTRUCTIONS

BLUE SALMON

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RJ201 IS IN TARGET SQUARE 111G

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- DUAL PURPOSE GUN POSITION (Empty)
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- AUTOMATIC AA
- COVERED ARTILLERY EMPLACEMENT
- RANGE FINDER
- UNIDENTIFIED INSTALLATION
- MACHINE GUN
- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
BY 64TH ENGR. TOP. BN. USAFICPA APRIL 1944
PHOTOGRAPHY FROM NAVY SORTIES, FEB. 1944
LOGICAL CONTOURS AND HYDROGRAPHY FROM ADVANCE COPY H.O. CHART NO. 12061 AND USMC. MAP JAN. 1934
DEFENSIVE INSTALLATIONS FROM PRISIC
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64TH ENGR BASE TOPO BN - OE 2308 - 5/51 - 2 C

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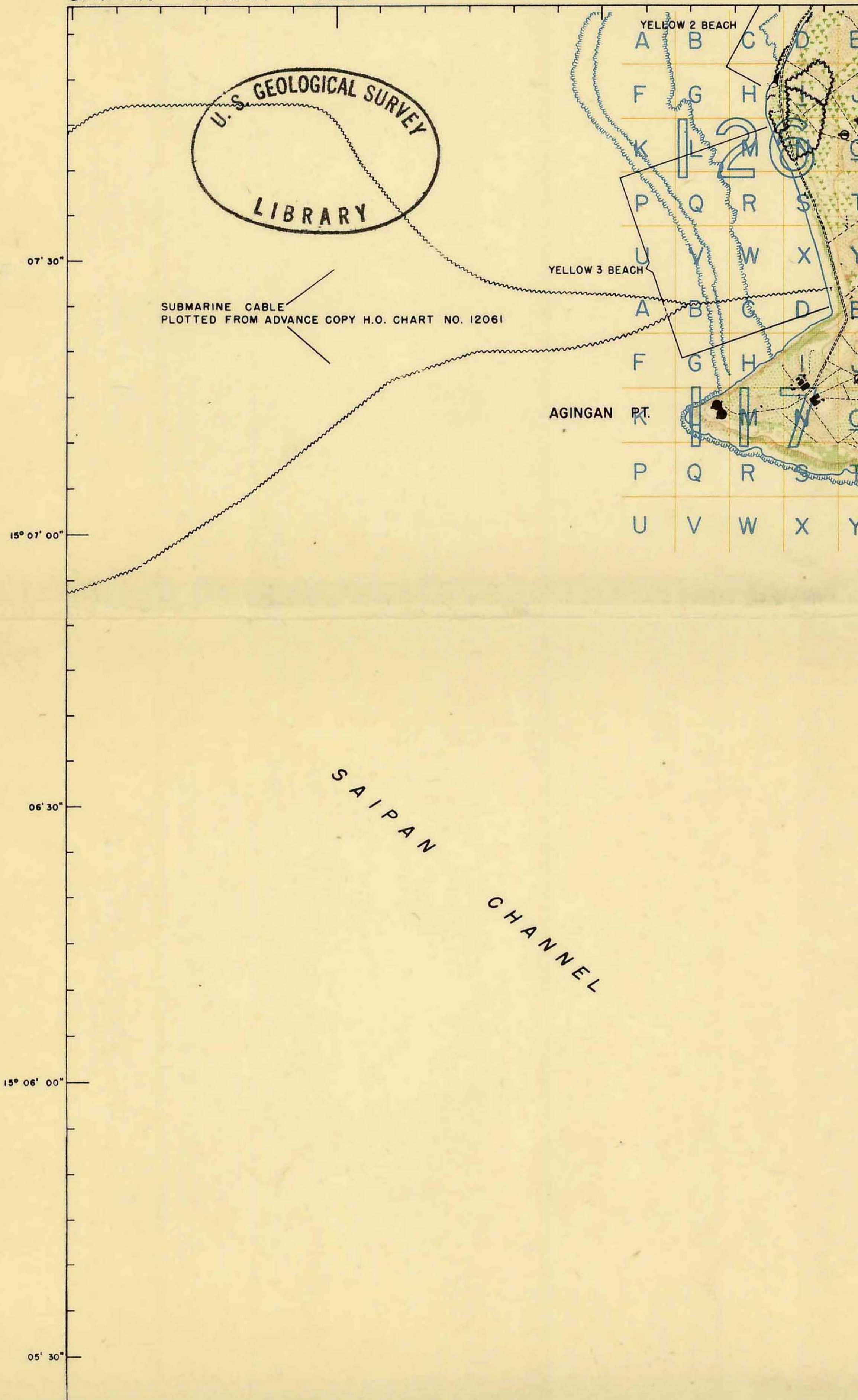
SCALE 1:20,000

POLYCONIC PROJECTION WITH 1000YD SPECIAL GRID

LEGEND

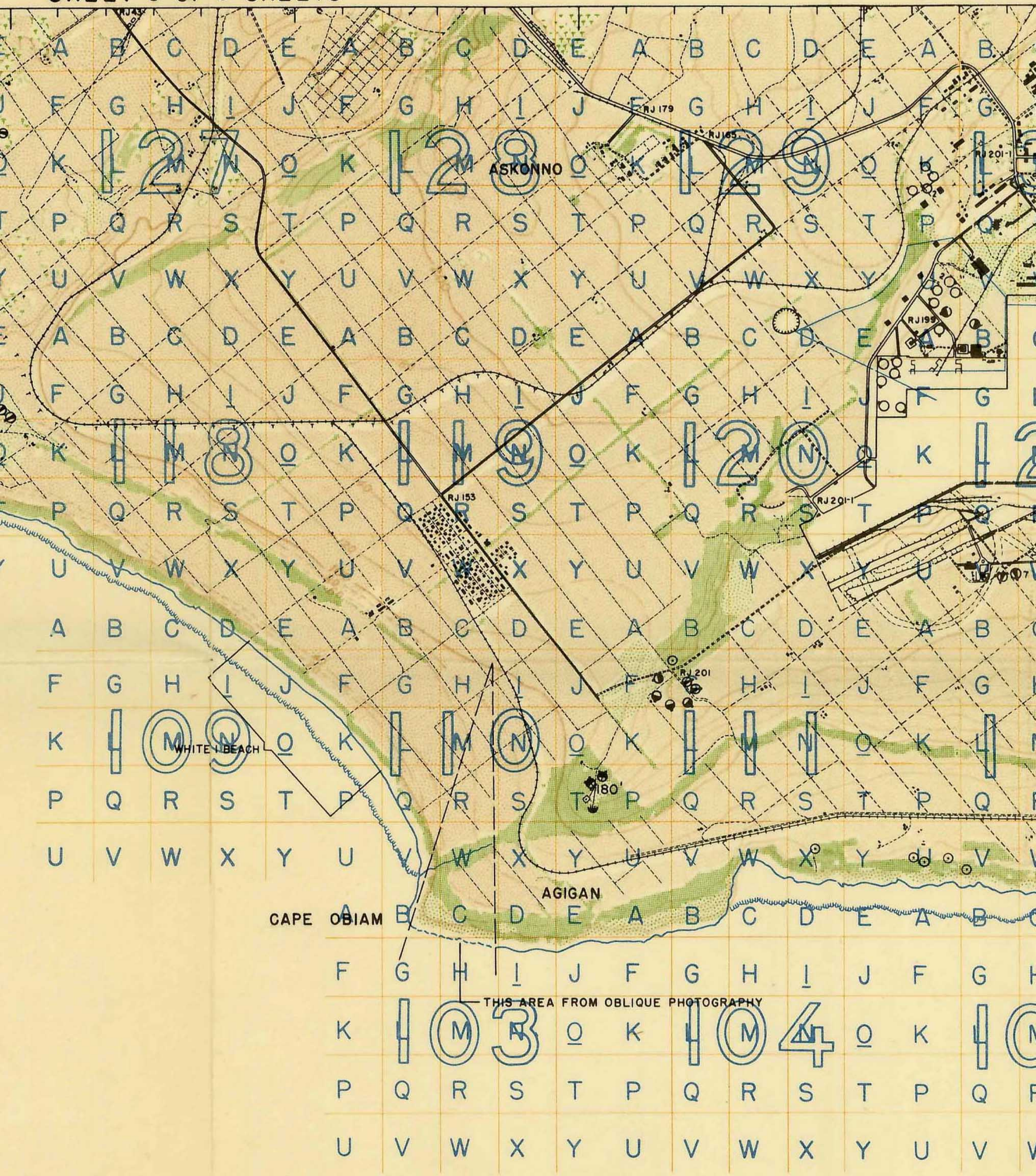
COCONUTS, LIGHT VEGETATION, HEAVY VEGETATION, CULTIVATED FIELDS, ROCKY BLUFFS, SAND BAR, VEGETATION (TYPE UNDETERMINED), TELEPHONE OR POWER LINE

SAIPAN – TINIAN AREA



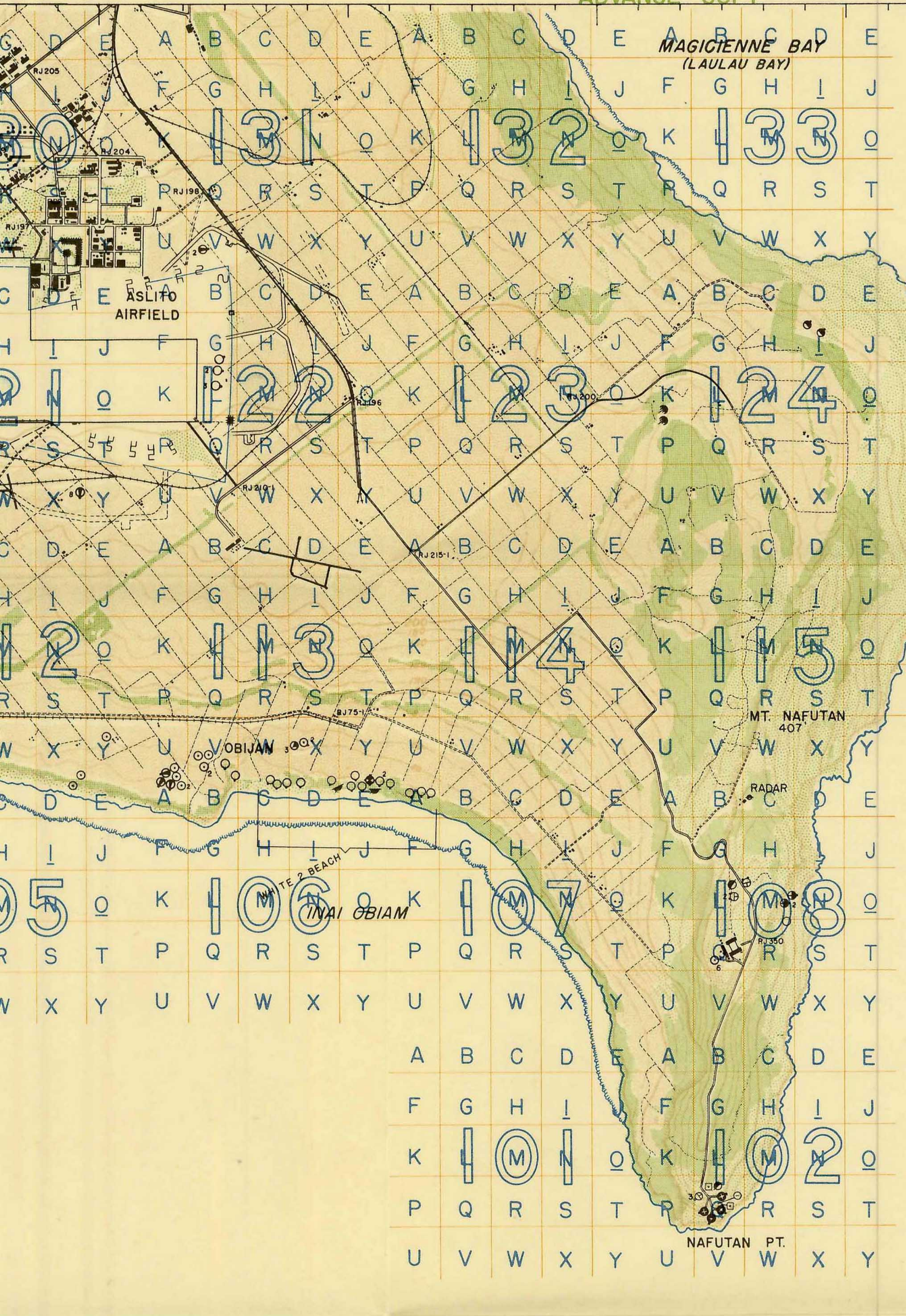
SHEET 5 OF 9 SHEETS

SPECIA



AL MAP

ADVANCE COPY



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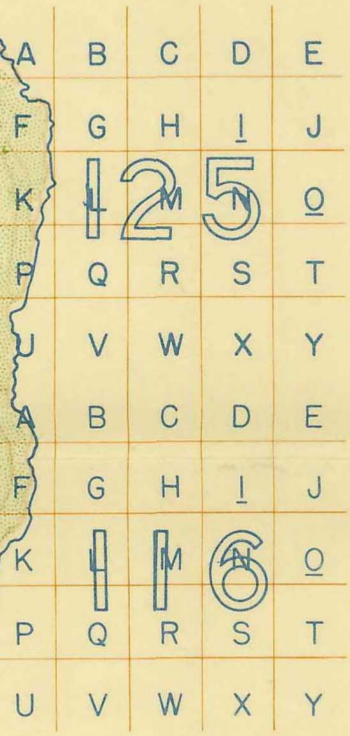
A B C D E
F G H I J
K L M N O
P Q R S T
U V W X Y
125
A B C D E
F G H I J
K L M N O
P Q R S T
U V W X Y
116

15°05' 00"

04' 30"

15° 04' 00"

03' 30"

40' 30" 45°41' 00" 41' 30" 145

PREPARED FOR JOINT INTELLIGENCE CENTER P.O.A.
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FROM AVAILABLE SOUR
SHOULD BE FORWARDE

5° 42' 00"

42' 30"

145° 43' 00"

43' 30"

COMPILED FROM AERIAL PHOTOGRAPHS WITHOUT ADVANTAGE OF
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RCES OF INFORMATION. CORRECTIONS AND OTHER COMMENTS
D TO JOINT INTELLIGENCE CENTER, PACIFIC OCEAN AREAS, P.H.

SCALE

1000 500 0 1

POLYCONIC PROJECTION · V

145° 44' 00"

44' 30"

145° 45' 00"

45' 30"

NOTE- CONTOURS BY 29TH ENGR TOPO BN, APRIL 1944 UTILIZING M
AERO PROJECTORS FROM SINGLE LENS AERIAL PHOTOGRAPHY
TO BASE MAP BY 64TH ENGR TOPO BN USAFICPA

1:20,000

000

2000

3000 YDS.

WITH 1000 YD. SPECIAL GRID

SPECIAL AIR AND GUNNERY TARGET MAP
SHEET 5 OF 9 SHEETS SCALE 1 : 20,000

APPROVED:

R.K. TURNER, VICE ADMIRAL, USN
COMMANDER 5 TH AMPHIBIOUS FORCE

INSTRUCTIONS

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- BLOCKHOUSE
- PILLBOX
- RADAR
- SEARCHLIGHT
- COMMAND POST
- OBSERVATION TOWER

145° 46' 00"   46' 30"   145° 47' 00"

MULTIPLEX ADJUSTED

LEGEND

COCONUTS	ROCKY BLUFFS
LIGHT VEGETATION	SAND BAR
HEAVY VEGETATION	VEGETATION (TYPE UNDETERMINED)
CULTIVATED FIELDS	TELEPHONE OR POWER LINE

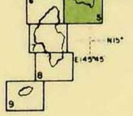


TABLE 2. DISTRIBUTION OF FORAMINIFERA BY AREAS AND COLLECTING STATIONS

Area	Formation	Stations
Cliff west of Pēpo	Mariiru l.s.	188, 139, 296, 297, 298, 299
Cliff east of Hirippo	Mariiru l.s.	345, 300, 431, 346, 189
	H.	190
Cliff west of Hirippo	Mu	419
	Taihanom	391, 392, 433, 127B, 127A
	Hirippo l.s.	472, 473, 426, 423, 422, 428
	Ponia	421, 420
Cliff west of Taihanom	Mariiru l.s.	165A, 165B, 165C, 281, 437, 439, 283
	Taih'm	440, 441, 288
	Ponia	289
Gagane cut	Mariiru l.s.	409, 118A, 118B, 118BC, 118C, 118D
Along Ponia line	Mu	464
	Taihanom	465, 119, 336, 445, 444
	Hirippo l.s.	256, 262, 264, 255, 120
	P	315
Gagane coast	Mu	459, 460
	Taihanom l.s.	268, 271, 272, 274, 275, 331, 277
Cliff west of Haofuniya	Mu	475, 343
	T	480, 310
	H	140
Cut south of Teruson	Taihanom	328A, 328B, 125, 468
Mariiru area	Mariiru	355, 361, 362
	Taihanom	154, 155, 357, 358, 356
	Hirippo	354, 454, 457, 152
Below cliff E. of Taihanom	Mariiru	253
So. of cliff W. of Taihanom	Mariiru	446
On the cliff west of Taihanom	Mariiru	482
South of Parie	T	373
Hirippo	Hirippo limestone	303, 304
West of the cliff west of Taihanom	Hirippo limestone	166A, 167B, 170
Pēpo	Hirippo limestone	387, 388, 316, 136, 137
Farm spring	Hirippo limestone	143B, 247
Between Chego and Fusudorina	Hirippo limestone	231, 234
Coast of So. Taipinkoto	Hirippo limestone	400
Below the cliff north of Gagane	Hirippo limestone	245
Cliff W. of Taihanom	Ponia limestone	470, 128
South of Rupoku	Ponia limestone	312
Between Sonson & Teruson	Ponia limestone	403
Fusudorina	Ponia limestone	232
East of Ganpaapa	Ponia limestone	78
Northwest of Mt. Manira	Mariana limestone	51
West of Chego	Mariana limestone	115
Sonson spring	Mariana limestone	46, 47
South of Fusudorina	Mariana limestone	57
Lugi	Mariana limestone	79
North of Shinaparu	Mariana limestone	82
Makemanaku	Mariana limestone	92
West of Taihanom	Mariana limestone	166B, 167A, 168
East of Poniya	Mariana limestone	121
Asonan	Mariana limestone	143A, 149
Northeast of Parie	Mariana limestone	157
Taipinkoto	Mariana limestone	178
Coast east of Rijeo	Mariana limestone	75
Tatacho	Rota l.s.	11
Mochon	Rota l.s.	100
Arijia	Rota l.s.	106
West of Aueniya	RBD	122A
Teteto	RBD	97
Coast north of Taipinkoto	R.l.s.	195

Species (rows):

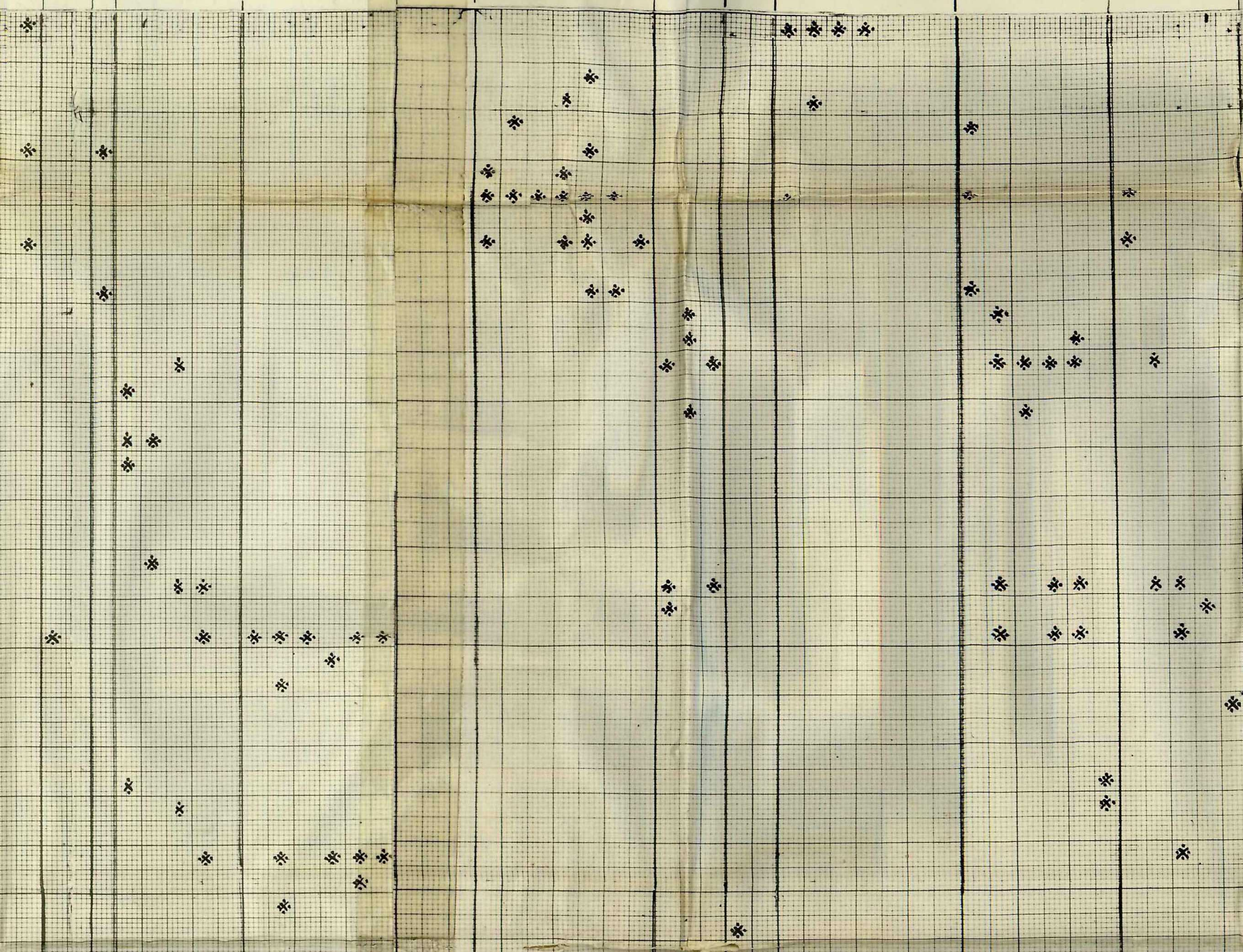
Camerina
Camerina?
Pellatispira
Pallatispira?
Biplanispira mirabilis (Umbgrove)
Biplanispira
Biplanispira?
Discocyclina
Asterocyclina sp.
Fabiania-like form n. gen.
Polylepidina
Spiroclypeus vermicularis Tan Sin Hok
Spiroclypeus leupoldi v. d. Vlerk
Spiroclypeus margaritatus Schlumberger
Spiroclypeus
Spiroclypeus ?
Lepidocyclina (Eulepidina) formosa (Schlumberger)
Lepidocyclina (Eulepidina) formosa (Schlumberger)?
Lepidocyclina (Eulepidina) gibbosa (Yabe)
Lepidocyclina (Eulepidina) globosa Yabe
Lepidocyclina (Eulepidina) monstrosa (Yabe)
Lepidocyclina (Eulepidina) richthofeni (Smith)
Lepidocyclina (Eulepidina) n. sp.
Lepidocyclina (Eulepidina)
Lepidocyclina (Nephrolepidina) sumatrensis (Brady)
Lepidocyclina (Nephrolepidina)
Lepidocyclina (Nephrolepidina) ?
Lepidocyclina (Multilepidina) irregularis Hanzawa ?
Lepidocyclina (Nephrolepidina) angulosa Provali ?
Lepidocyclina (Amphilepidina)
Miogypsinoides n. sp. (aff complanata) ?
Miogypsinoides
Miogypsina
Flosculinella (Globulus type) n. sp.
Cycloclypeus communis Martin
Cycloclypeus (Katacycloclypeus) annulatus
Cycloclypeus (Katacycloclypeus?)
Cycloclypeus carpenteri Brady
Cycloclypeus Carpenteri Brady ?
Cycloclypeus
Carpenteria montipora
Carpenteria proteiformis Göes
Carpenteria proteiformis Göes ?
Carpenteria
Sporadotrema cylindrica Carter
Sporadotrema
Heterostegina bornensis v. d. Vlerk
Heterostegina bornensis v. d. Vlerk ?
Heterostegina depressa d'Orbigny
Heterostegina
Amphistegina radiata (Fichtell & Moll)
Amphistegina
Acervulina inhaerens Schultze
Acervulina inhaerens Schultze plana Carter
Acervulina n. sp.
Acervulina
Planorbulinella larvata (Parker & Jones)
Planorbulinella
Rotalia gaimardi d'Orbigny
Rotalia schroeteriana Parker & Jones
Rotalia
Globigerina bulloides d'Orbigny
Globigerina
Gypsina globulus Reuss
Gypsina vesicularis (Parker & Jones)
Gypsina vesicularis (P. & J.) discus Göes
Gypsina inhaerens Schultze
Gypsina
Borelis pygmaeus Hanzawa
Sorites martini ?
Sorites ?
Orbulina universa d'Orbigny
Orbulina
Pulleniatina obliquiloculata (Parker & Jones)
Baculogypsina sphaerulata (Parker & Jones)
Calcarina spengleri (Gmelin)
Calcarina
Miniacena miniacea (Pallas)
Homotrema rubrum (Lamarck)
Marginopora vertebralis Quoy & Gaimard
Marginopora
Operculina
Operculinella venosa Fichtel & Moll
Operculinella cumingii
Operculinella
Spiroloculina canaliculata d'Orbigny
Textularia
Triloculina trigonula (Lamarck)
Discocyclina n. sp.
Planorbulinella type n. gen.

No. 1421

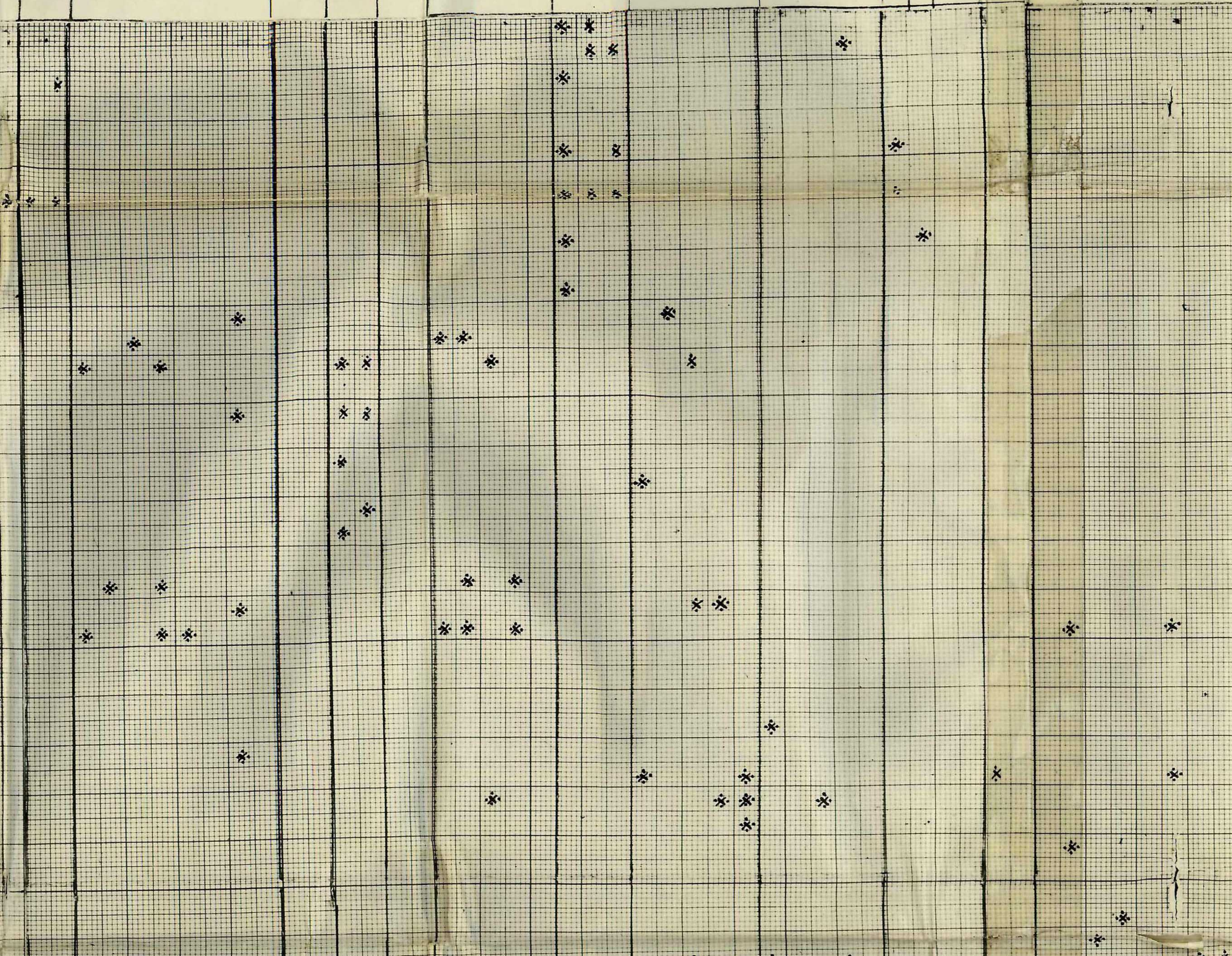
[TABLE 2. DISTRIBUTION OF FORAMINIFERA BY AREAS AND COLLECTING STATIONS]

	Cliff west of Pēpo						Clif[f] of H[…]		
	Mariiru l.s.						Mariiru		
	188	139	296	297	298	299	345	300	431
Camerina				*			*	*	
Camerina?									
Pellatispira				*		*		*	*
Pallatispira?									
Biplanispira mirabilis (Umbgrove)									
Biplanispira		*				*			
Biplanispira?									
Discocyclina	*	*	*	*	*		*	*	
Asterocyclina sp.									
Fabiania-like form n. gen.	*	*		*				*	*
Polylepidina									
Spirocyclypeus vermicularis Tan Sin Hok			*						
Spirocyclypeus leupoldi v. d. Vlerk									
Spirocylypeus margaritatus Schlumberger									
Spirocylypeus									
Spirocylypeus ?									
Lepidocyclina (Eulepidina) formosa (Schlumberger)									
Lepidocyclina (Eulepidina) formosa (Schlumberger)?									
Lepidocyclina (Eulepidina) gibbosa (Yabe)									
Lepidocyclina (Eulepidina) globosa Yabe									
Lepidocyclina (Eulepidina) monstrosa (Yabe)									
Lepidocyclina (Eulepidina) richthofeni (Smith)									
Lepidocyclina (Eulepidina) n. sp.									
Lepidocyclina (Eulepidina)									
Lepidocyclina (Nephrolepidina) sumatrensis (Brady)									
Lepidocyclina (Nephrolepidina)									
Lepidocyclina (Nephrolepidina)?									
Lepidocyclina (Multilepidina) irregularis Hanzawa?									
Lepidocyclina (Nephrolepidina) angulosa Provale?									
Lepidocyclina (Amphilepidina)									
Miogypsinoides n. sp. (aff complanata)?									
Miogypsinoides									
Miogypsina									
Flosculinella (Globulus type) n. sp.									
Cycloclypeus communis Martin									
Cycloclypeus (Katacycloclypeus) annulatus									
Cycloclypeus (Katacycloclypeus)?)									
Cycloclypeus carpenteri Brady									

f east irippo		Cliff west of Hirippo			Cliff west of Taihanom			Gagane cut	Along Ponia line		
l.s.	H.	Mu	Taihanom	Hirippo l.s.	Ponia	Mariiru l.s.	Taih'm	Ponia	Mariiru l.s.	Mu Taihanom	Hirippo l.s.
346 189	190	419	391 392 433 127B 127A	472 473 426 423 422 428	421 420	165A 165B 165C 281 437 439 283	440 441 288	289	409 118A 118B 118BC 118C 118D	464 465 119 336 445 444	256 262 264 255 120



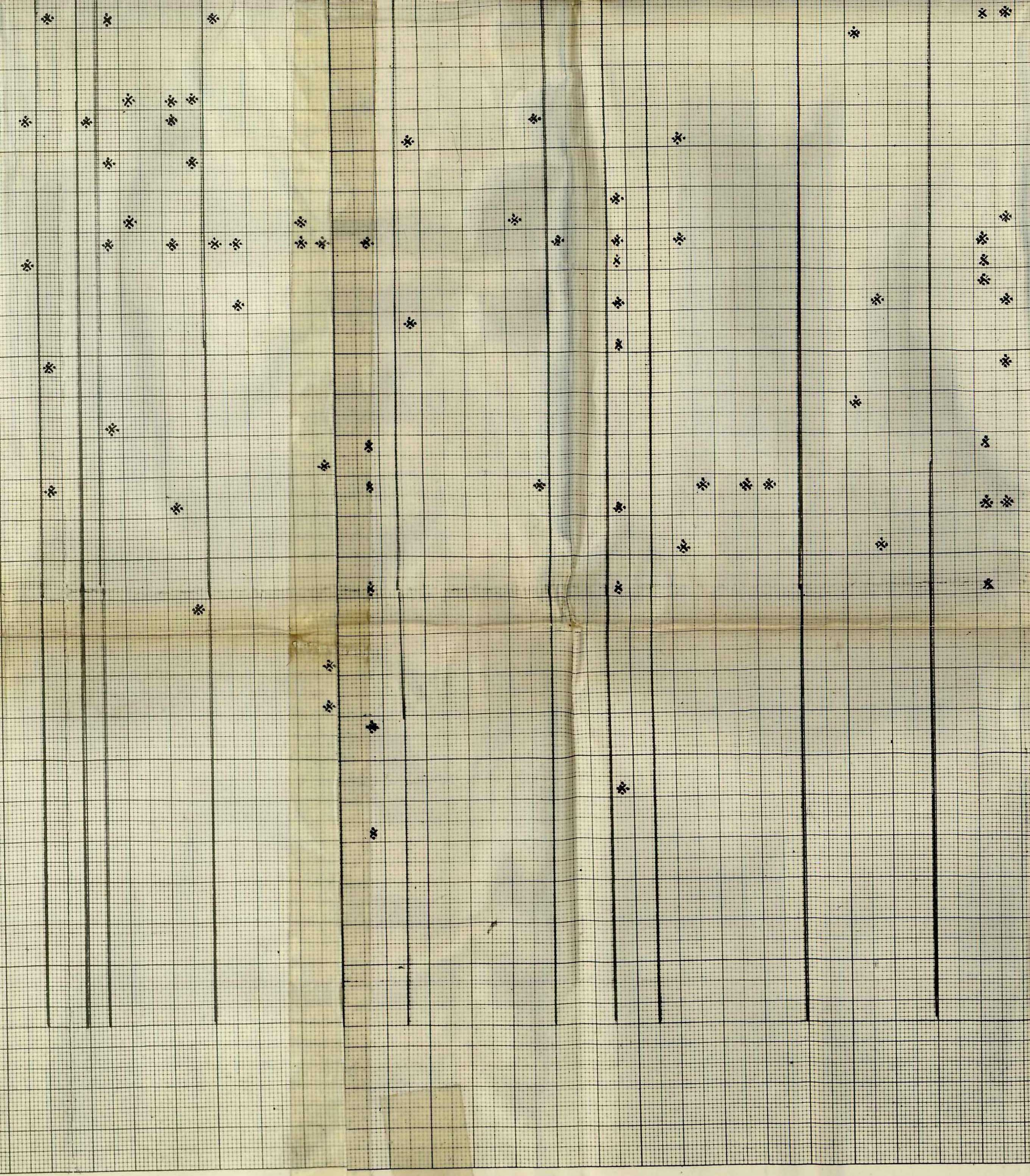
Locality	Unit	Samples
	P	315
Gagane coast	Mu	459, 460
	Taihanom l.s.	268, 271, 272, 274, 275, 331, 277
Cliff west of Haofuniya	Mu	475, 343
	T	480, 310
	H	140
Cut south of Teruson	Taihanom	328A, 328B, 125, 468
Mariiru area	Mariiru	355, 361, 362
	Taihanom	154, 155, 357, 358, 356
	Hirippo	354, 454, 457, 152
Below cliff E.of Taihanom	Mariiru	253
So. of cliff W.of Taihanom		446
On the cliff west of Taihanom		482
South of Parie	T	373
Hirippo	Hirippo limeston	303, 304
West of the cliff west of Taihanom		166A, 167B, 170
Pepo		387, 388, 316

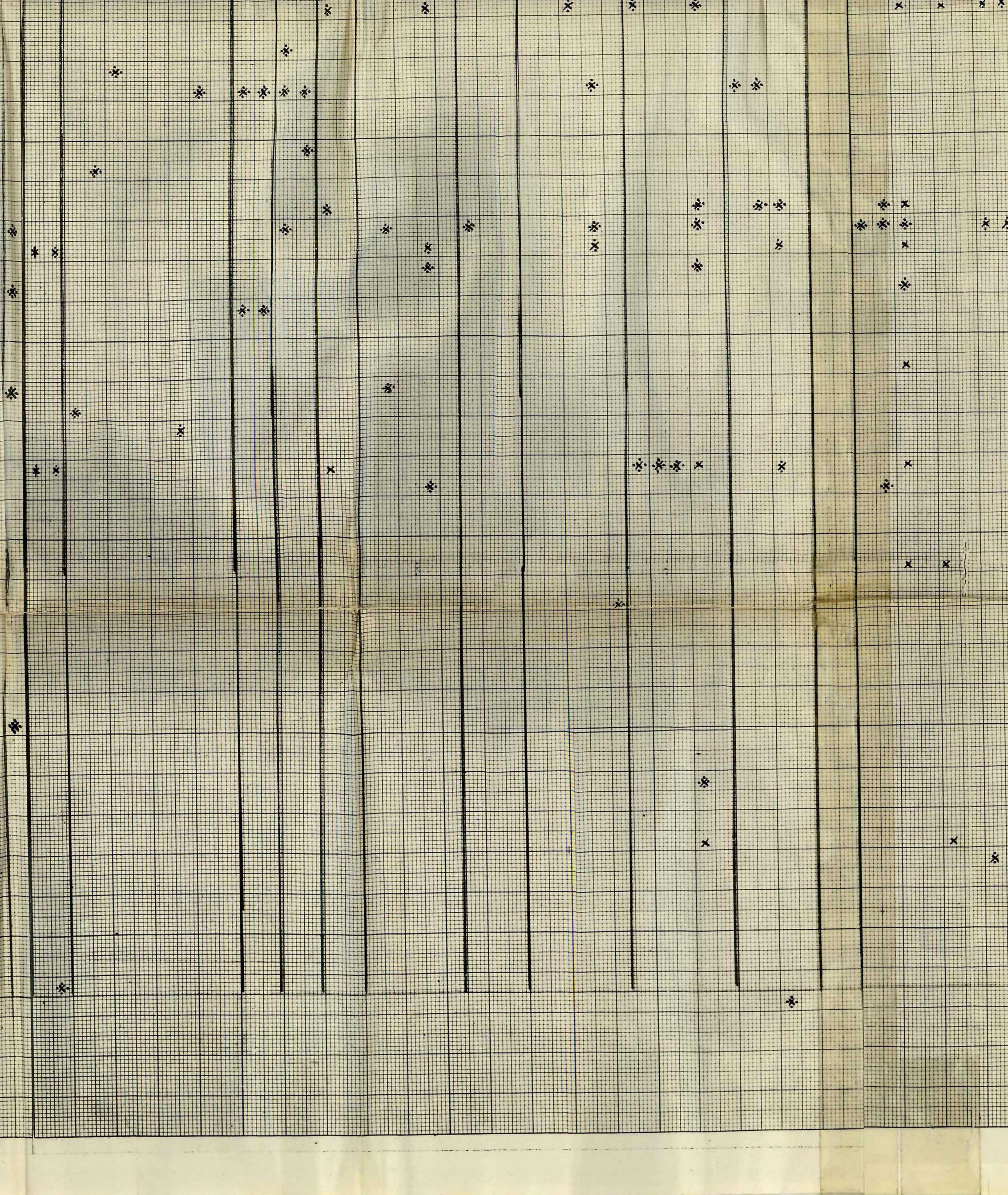


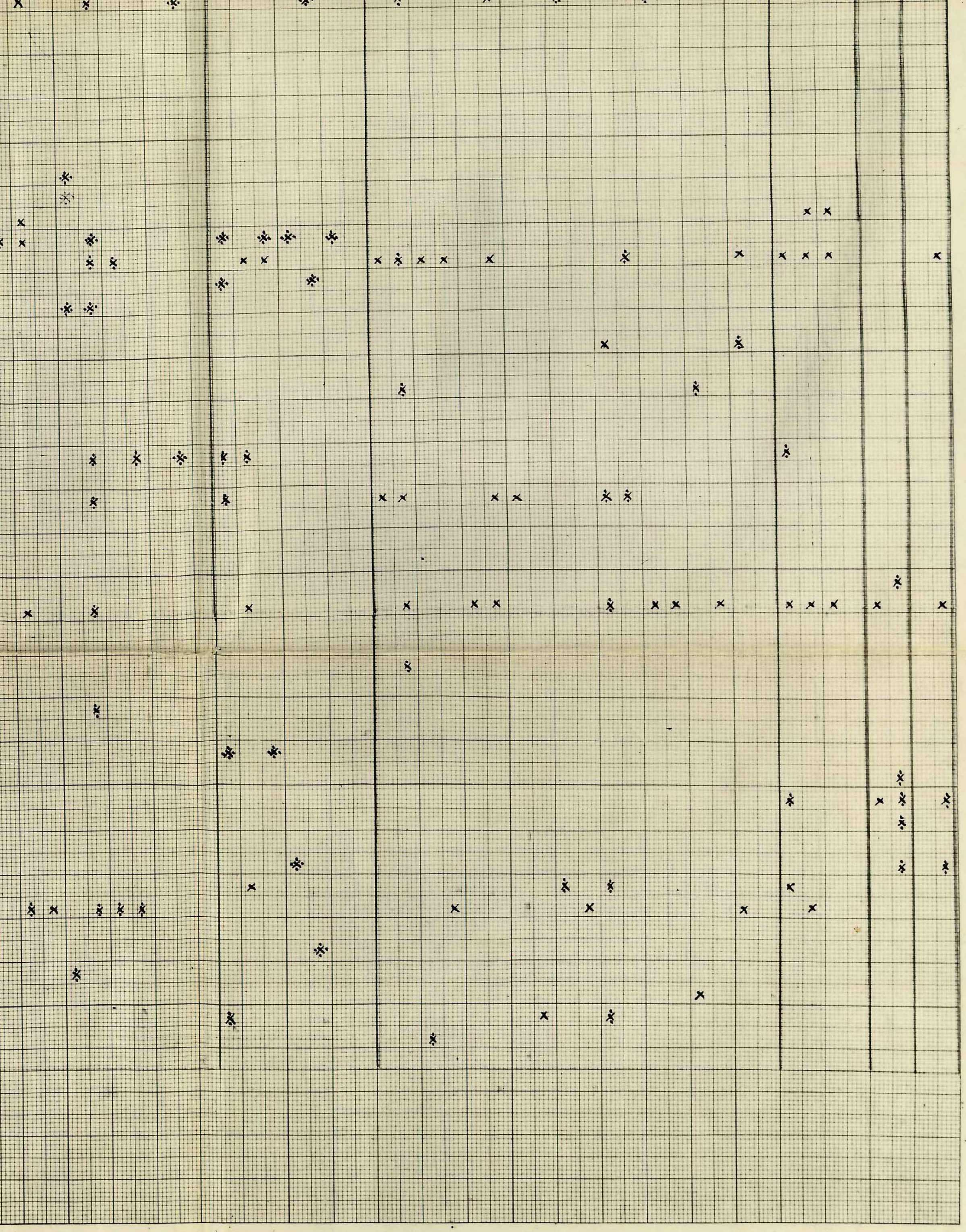
136 137	ne	
143B		Farm spring
247		
231 234		Between Chego and Fusudorina
400		Coast of So. Taipinkoto
245		Below the cliff north of Gagane
470	Ponia limestone	Cliff W. of Taihanom
128		
312		South of Rupoku
403		Between Sonson & Teruson
232		Fusudorina
78		East of Ganpaapa
51	Mariana limestone	Northwest of Mt. Manira
115		West of Chego
46 47		Sonson spring
57		South of Fusudorina
79		Lugi
82		North of Shinaparu
92		Makemanaku
166B 167A 168		West of Taihanom
121		East of Poniya
143A 149		Asonan
157		Northeast of Parie
178		Taipinkoto
75		Coast east of Rijeo
11	Rota l.s	Tatacho
100		Mochon
106		Arijia
122A	RBD	West of Aueniya
97		Teteto
195	R.l.s	Coast north of Taipinkoto

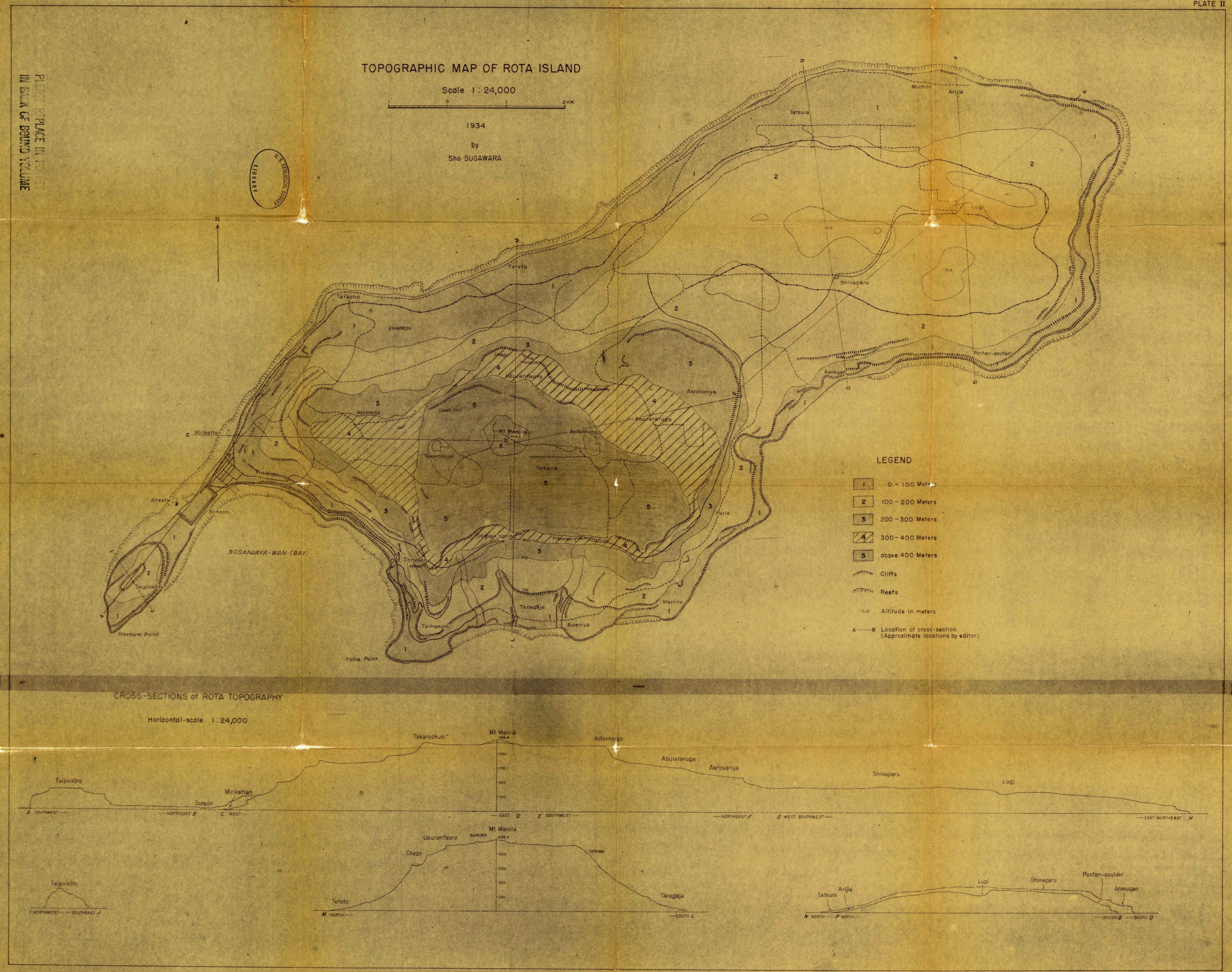
Cycloclypeus carpenteri Brady ?
Cycloclypeus
Carpenteria montipora
Carpenteria proteiformis Göes
Carpenteria proteiformis Göes ?
Carpenteria
Sporadotrema cylindrica Carter ※
Sporadotrema
Heterostegina bornensis v. d. Vlerk
Heterostegina bornensis v. d. Vlerk ?
Heterostegina depressa d'Orbigny
Heterostegina
Amphistegina radiata (Fichtell & Moll)
Amphistegina
Acervulina inhaerens Schultze
Acervulina inhaerens Schultze plana Carter ※ ※
Acervulina n. sp.
Acervulina
Planorbulinella larvata (Parker & Jones) ※
Planorbulinella
Rotalia gaimardi d'Orbigny
Rotalia schroeteriana Parker & Jones ※ ※
Rotalia
Globigerina bulloides d'Orbigny ※
Globigerina
Gypsina globulus Reuss
Gypsina vesicularis (Parker & Jones)
Gypsina vesicularis (P & J.) discus Göes
Gypsina inhaerens Schultze
Gypsina
Borelis pigmens Hanzawa
Sorites martini ?
Sorites ?
Orbulina universa d'Orbigny
Orbulina
Pulleniatina obliquiloculata (Parker & Jones)
Baculogypsina sphaerulata (Parker & Jones)
Calcarina spengleri (Gmelin)
Calcarina
Miniacina miniacea (Pallas)
Homotrema rubrum (Lamarck)
Marginopora vertebralis Quoy & Gaimard
Marginopora
Operculina
Operculinella venosa Fichtel & Moll
Operculinella cumingii
Operculinella
Spiroloculina canaliculata d'Orbigny
Textralia
Triloculina trigonula (Lamarck)
Discorbina n. sp.
Planorbulinella type n. gen.

No. 1421








TOPOGRAPHIC MAP OF ROTA ISLAND
Scale 1 : 24,000
1934
by
Sho SUGAWARA
LEGEND
0 - 100 Meters
100 - 200 Meters
200 - 300 Meters
300 - 400 Meters
above 400 Meters
Cliffs
Reefs
Altitude in meters
Location of cross-section
(Approximate locations by editor)
SOSANJAYA-WAN (BAY)
Mt. Manila
Sabana
Asfantango
Aburafaruga
Asrosariya
Takarookun
Uzuranfauro
Chego
Teteto
Tatacho
Mirikattan
Sonson
Taipinkoto
Harnum Point
Ponia Point
Tatsura
Mochon
Arijia
Lugi
Shinaparu
Pontan-asufan
Aaragan
Parie
Mariiru
Aueniya
Taragaja
Taihanom
Teruson
Sonsan spring
CROSS-SECTIONS of ROTA TOPOGRAPHY
Horizontal-scale 1 : 24,000
Anasugan
Pontan-asulani
SHRINE
SPRING


N

TOPOGRAPHIC MAP O

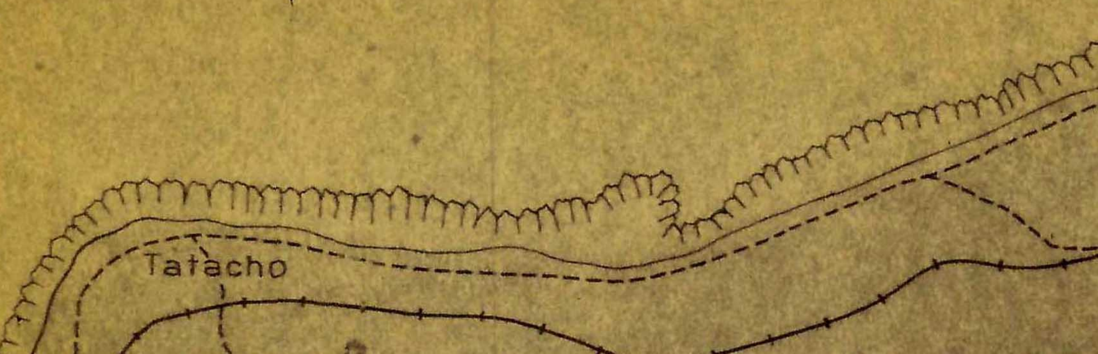
Scale 1 : 2

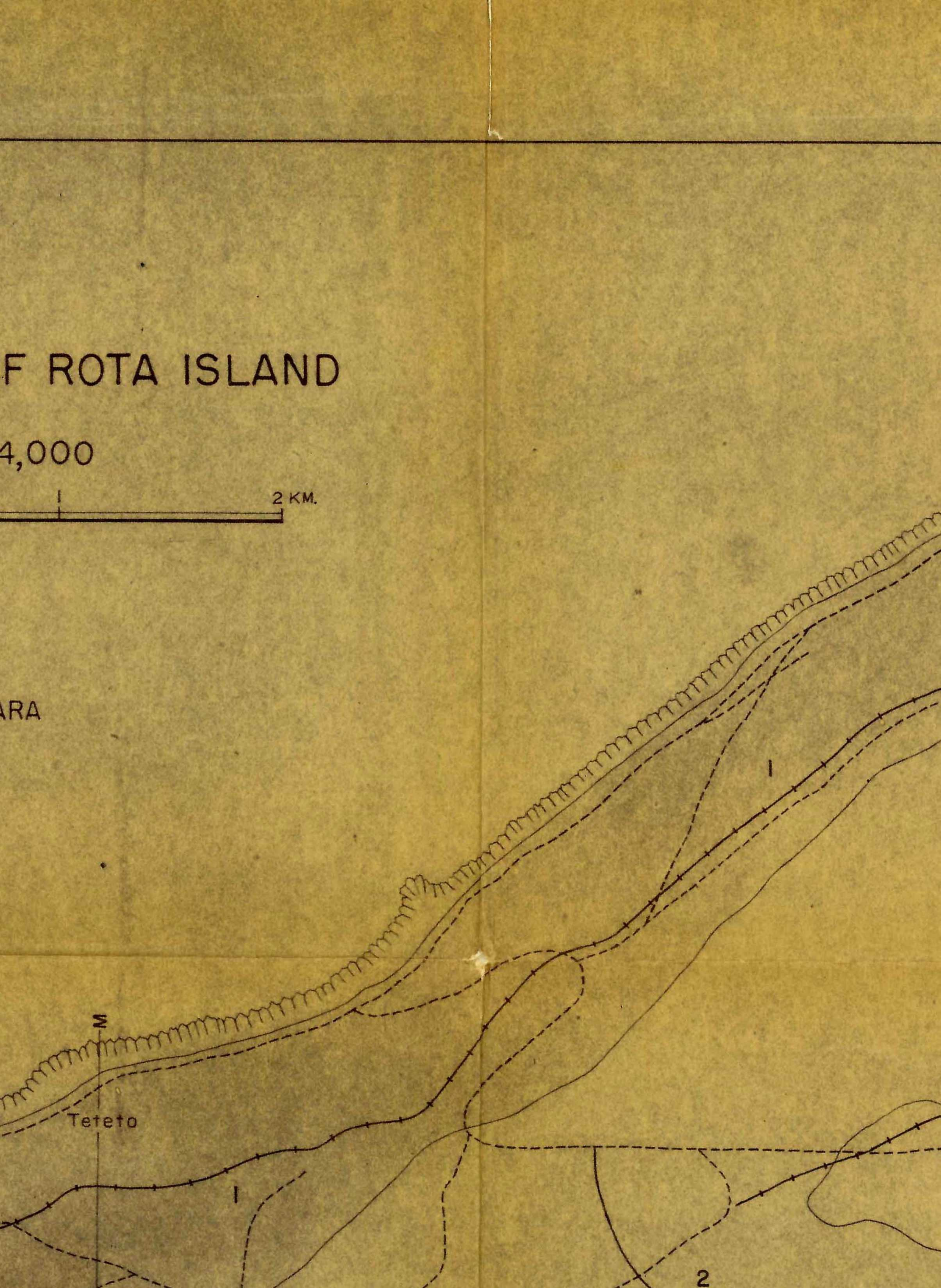
1 0

1934

by

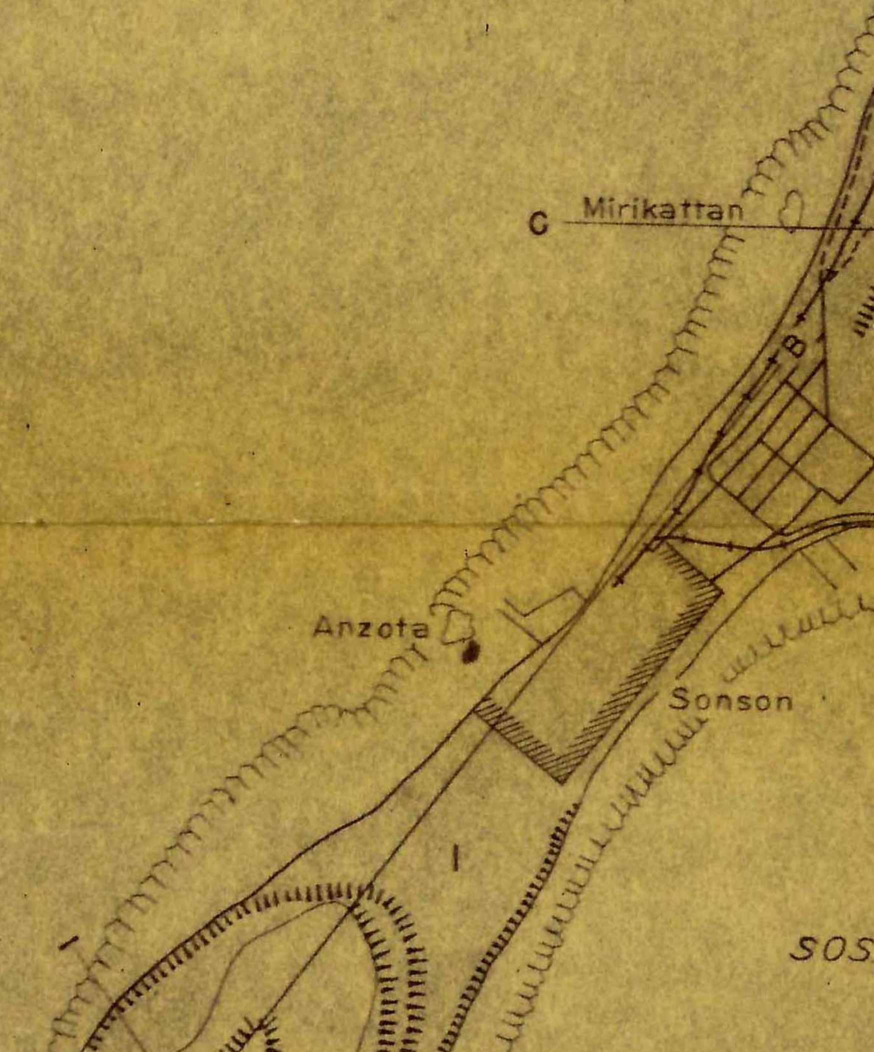
Sho SUGAWA




F ROTA ISLAND
4,000
1
2 KM.
ARA
M
Teteto
1
1
2


N
P
Mochon
Arijia
I
Iatsura
2
Lugi
181.8
170.8
Shinaparu

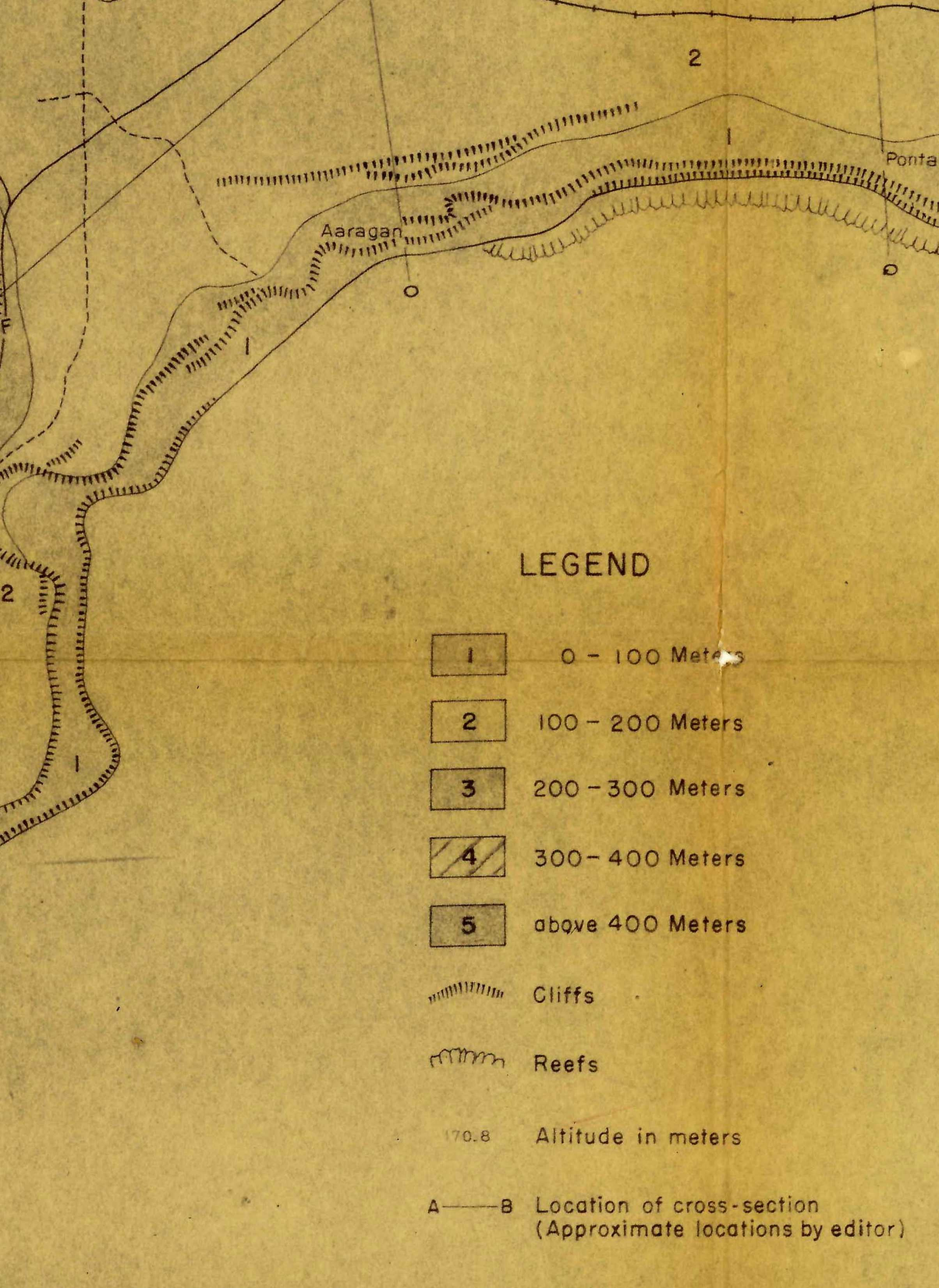
PLATE II

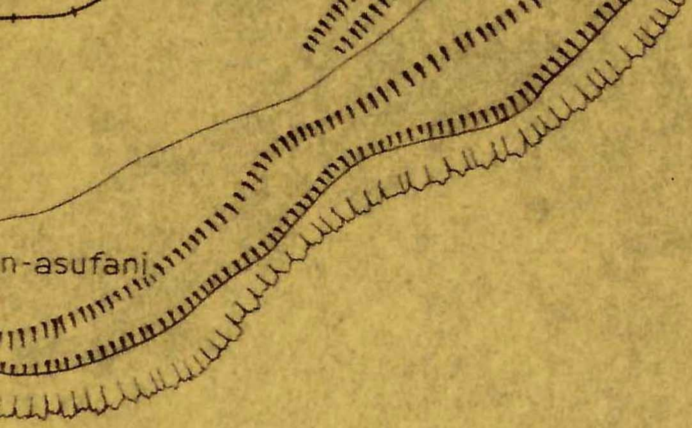


C
Mirikattan
B
Anzota
Sonson
1
SOS
2
Taipinkōto
A
1
Harnum Point

Finadēpo
1
2
3
Asyakeros
5
Iisan Hill
4
2
1
470.5
Takarookun
1
3
5
Sonsa
ANJAYA-WAN (BAY)
Teruson
4
2
Taihanom
1

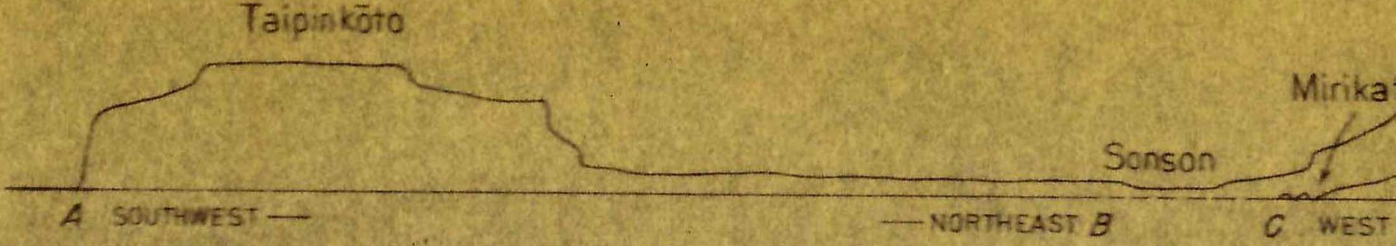
3
Chego
4
Uzuranfauro
3
Asrosariya
G
4
Aburataruga
Mt. Manila
496.4
D
E
Asfantango
475
Sabana
5
5
3
Parie
400
an spring
300
4
3
200
100
2
Mariiru
Taragāja
1
1
Aueniya

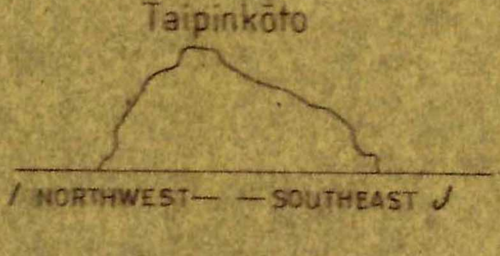

2
1
Ponta
Aaragan
1
2
1
LEGEND
1
0 - 100 Met
2
100 - 200 Meters
3
200 - 300 Meters
4
300 - 400 Meters
5
above 400 Meters
Cliffs
Reefs
70.8
Altitude in meters
A——B
Location of cross-section
(Approximate locations by editor)

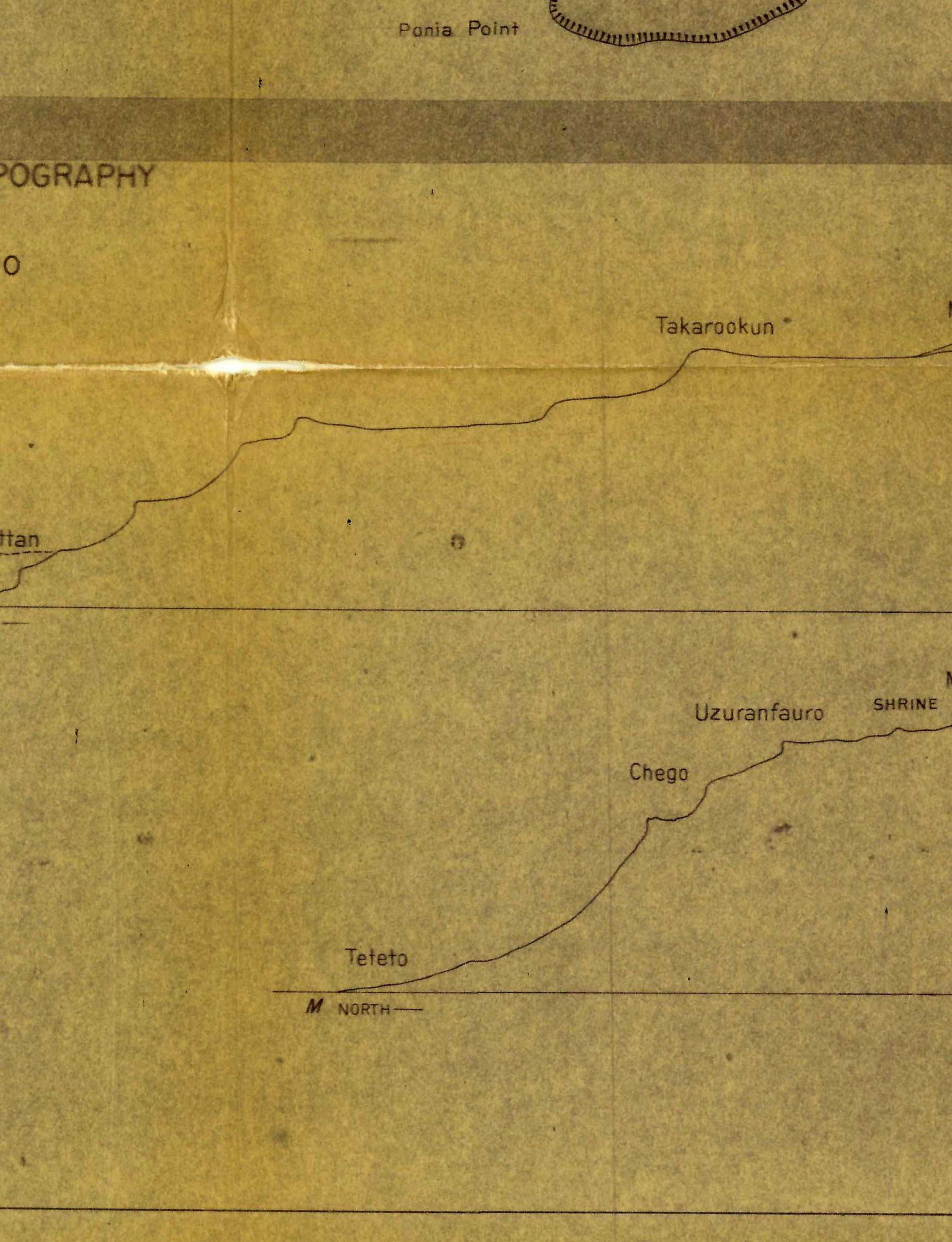

n-asufani

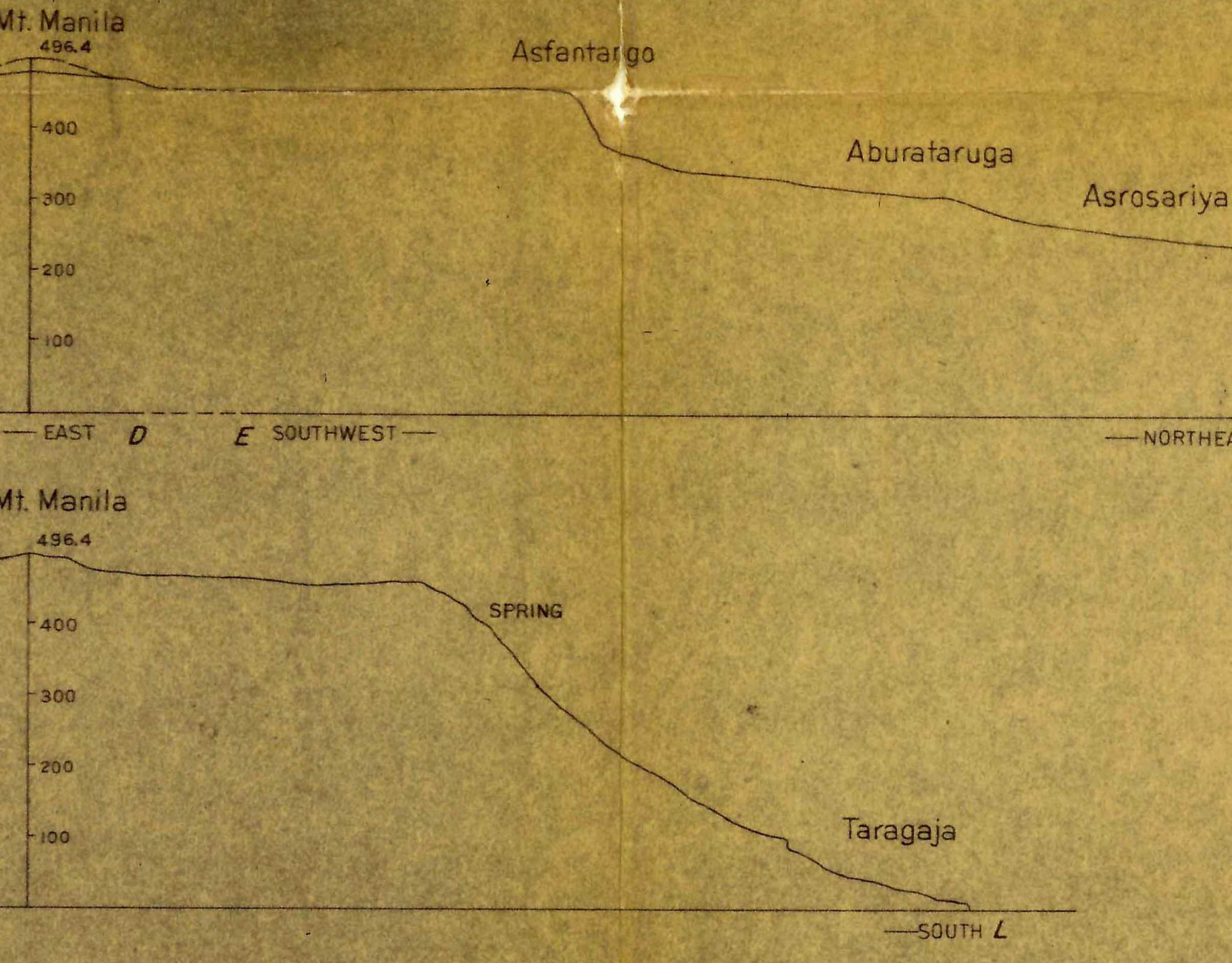
CROSS-SECTIONS of ROTA TOP

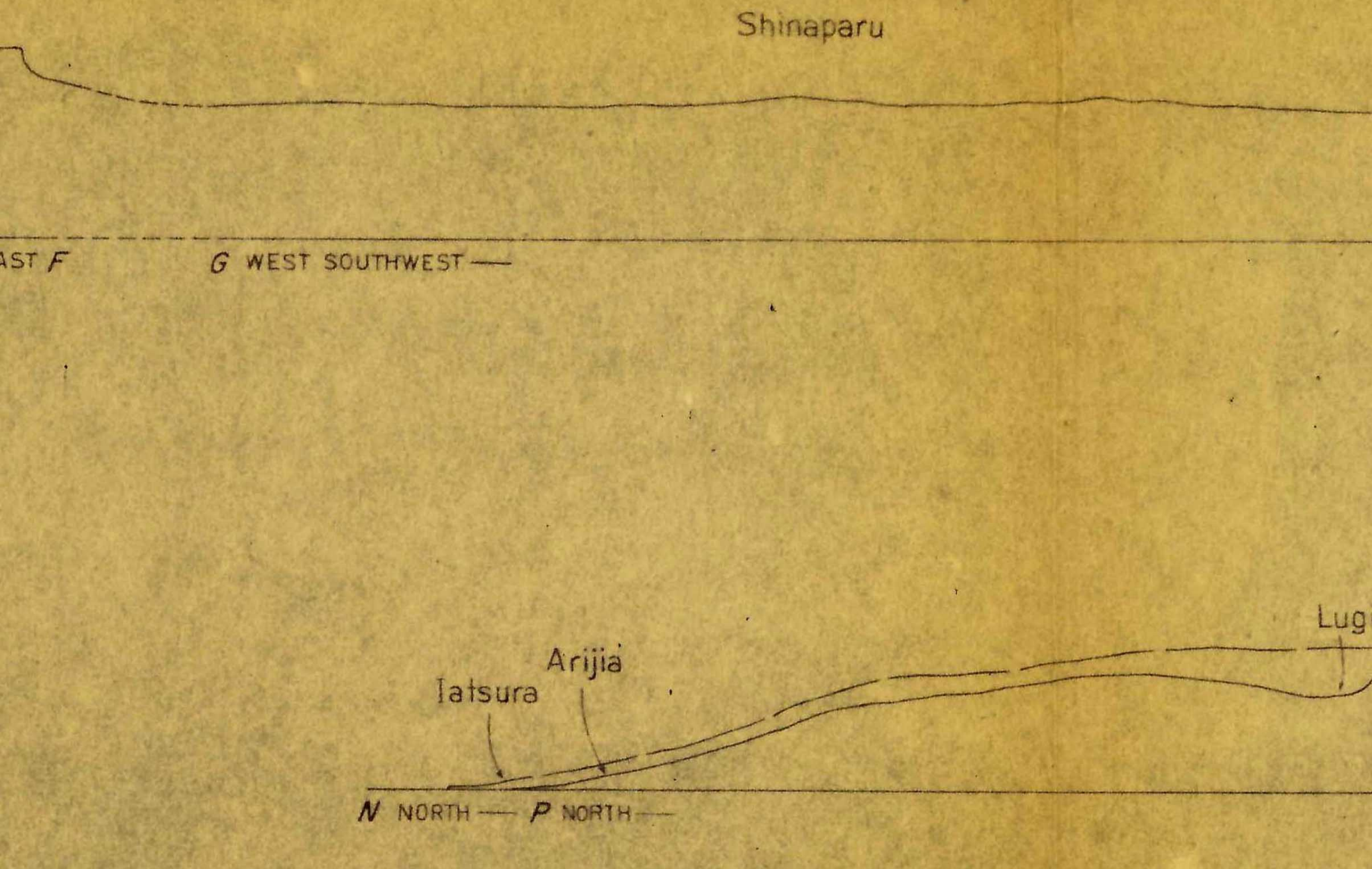
Horizontal-scale 1:24,00

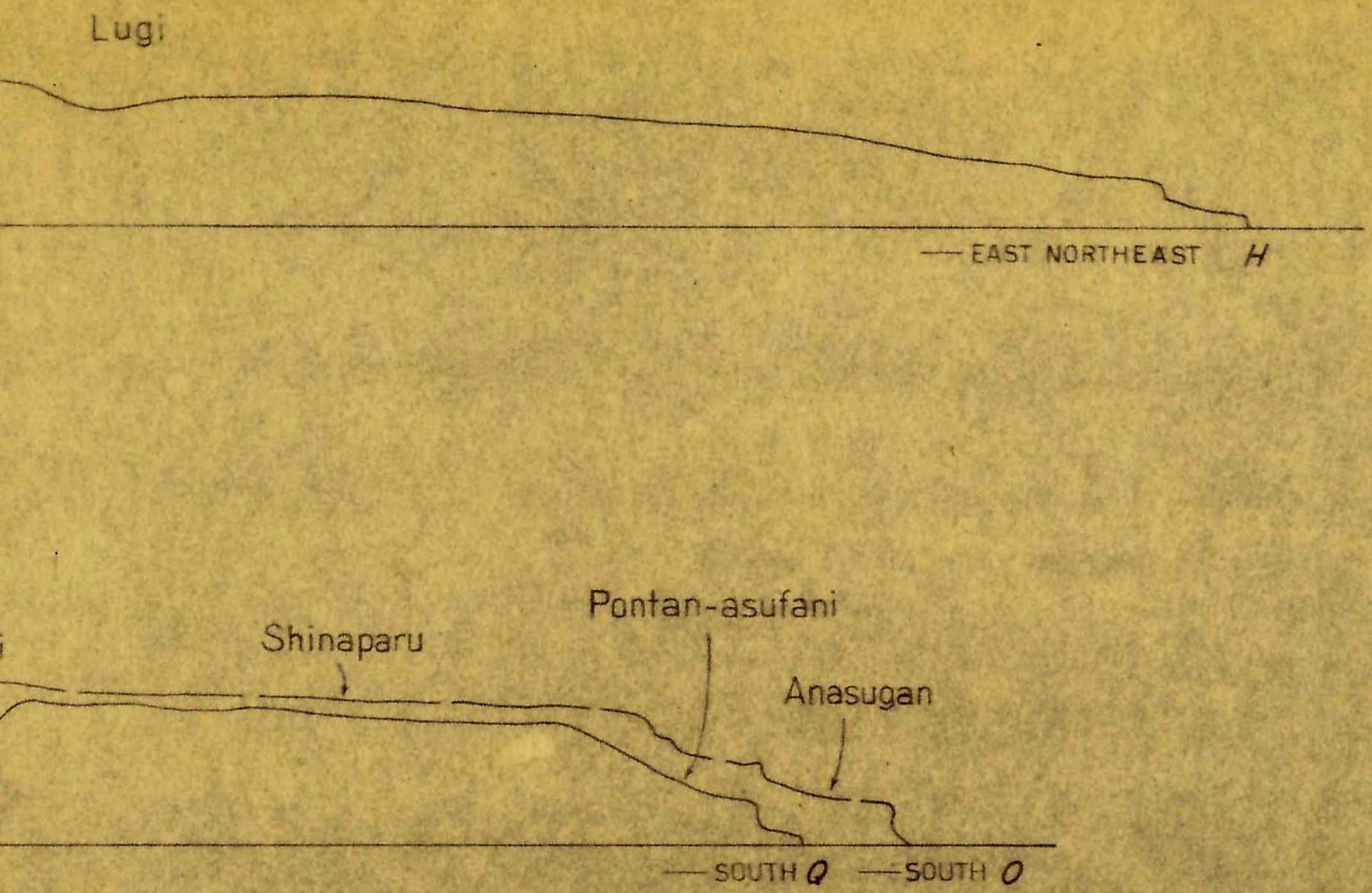





Ponia Point
POGRAPHY
O
Takarookun
ttan
Uzuranfauro
SHRINE
Chego
Teteto
M NORTH


Mt. Manila
496.4
Asfantango
400
300
200
100
Aburataruga
Asrosariya
EAST D
E SOUTHWEST
NORTHEA
Mt. Manila
496.4
SPRING
400
300
200
100
Taragaja
SOUTH L


Shinaparu
AST F
G WEST SOUTHWEST —
Arijia
Iatsura
Lug
N NORTH — P NORTH —



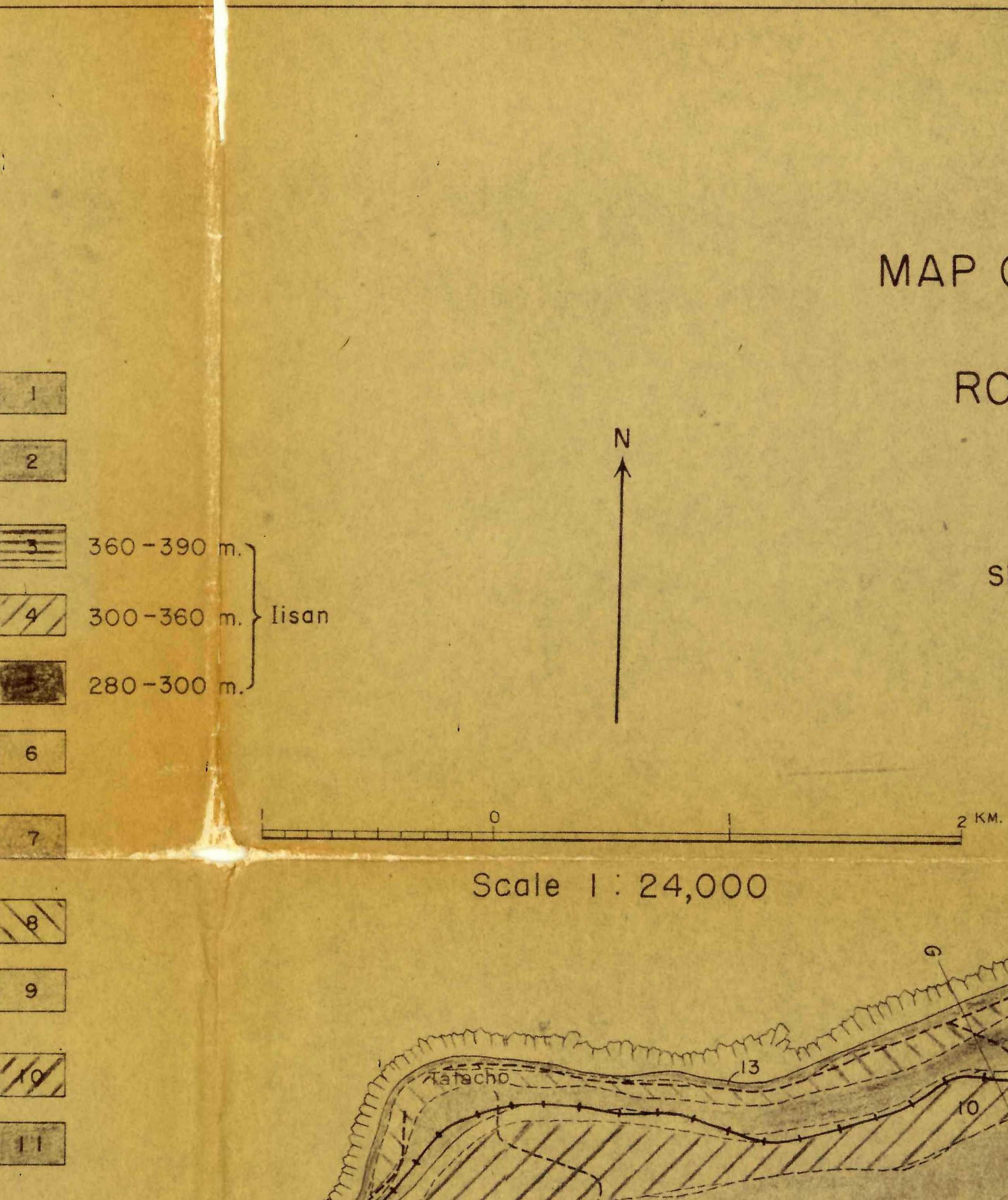
Lugi
EAST NORTHEAST H
Shinaparu
Pontan-asufani
Anasugan
SOUTH Q
SOUTH O

PLATE I


MAP OF TERRACES
ON
ROTA ISLAND
1934
by
Sho SUGAWARA
LEGEND
I SABANA TERRACE (470 m. altitude) Upper level 460 - 470 m. 1
Lower level 400 - 460 m. 2
II ABURATARUGA TERRACE (420 m. altitude) Uzuranfauro level 370 - 420 m. 3 360 - 390 m.
Aburataruga level 300 - 380 m. 4 300 - 360 m. Iisan
Asrosariya level 240 - 300 m. 5 280 - 300 m.
Asyakeros level 220 - 260 m. 6
III SHINAPARU TERRACE (200 m. altitude) 140 - 200 m. 7
IV LUGI TERRACE (150 m. altitude) Lugi level 100 - 150 m. 8
Benakan level 60 - 100 m. 9
V TARAGAJA TERRACE (60 m. altitude) Taragaja level 20 - 60 m. 10
Teruson level 20 m. 11
VI MIRIKATTAN TERRACE Sonson level 5 m. 12
Mirikattan level 4 m. 13
Precipice and fault scarp
Reefs
Aerial cableway
Altitude in meters
A — B Location of cross-section (Approximate locations by editor)
N
Scale 1 : 24,000
SOSANJAYA - WAN (BAY)
Harnum Point
Ponia Point
Sonson
Anzota
Mirikattan
Aan
Benakan
Abu
Rasgya
Asyakeros
Finadapo
Fusudorina
Chego
Uzuranfauro
Hirasuyaccot
Iisan Hill
Mt. Manila
Asfantango
Aburataruga
Sabana
Shinaparu
Rimpana
Teruson
Hirippo
Taihanom
Taragaja
Spring
Pasyahai
Pana
Aragon
Mochon
Lugi
CLIFFS and ROAD CUTS
of
The HIRIPPO AREA
Teruson cut
Gagane cut
Gagane cliff
Cliff west of Pepo
Cliff west of Haofuniya
Cliff east of Hirippo
Cliff west of Hirippo
Cliff west of Taihanom
Scale 1 : 12,000
CROSS-SECTION of TERRACES
Horizontal-scale 1 : 24,000
Uzuranfauro level
Sabana terrace
Surface at intermediate point
Iisan upper level
Iisan lower level
Iisan middle level
Chego
Aburataruga level
Asrosariya level
Asyakeros level
Siyasaja
Benakan level
Abu
Rasgya
Aan
Taipinkoto
Upper terrace
Middle terrace
Lower terrace
Sonson level
Mirikattan terrace
Hirippo
Taihanom
Taragaja level
Pasyahai
Ponia
Shinaparu terrace
Lugi terrace
400 m.
300 m.
200 m.
100 m.
0 m.

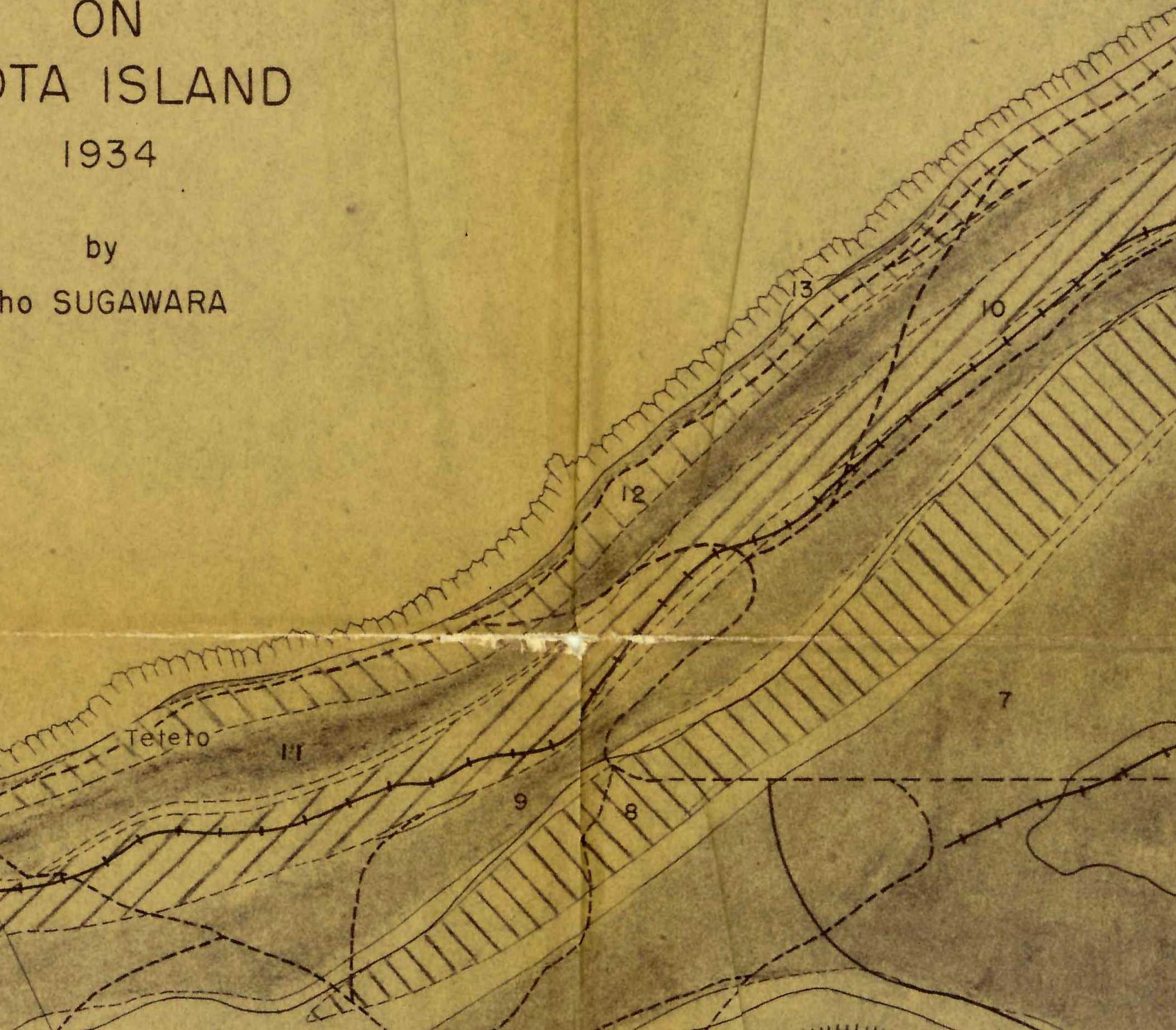
LEGEND

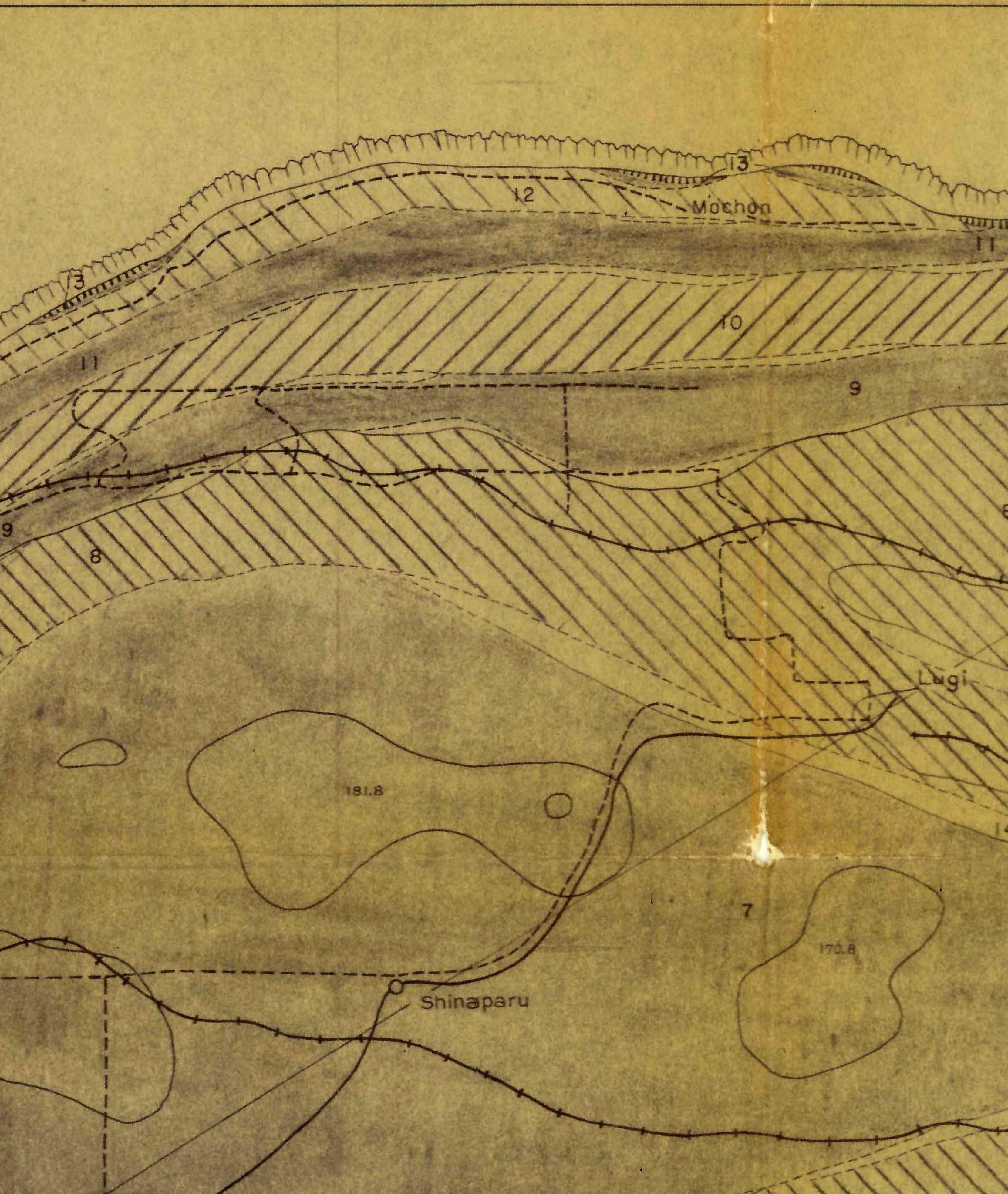
I	SABANA TERRACE *(470 m. altitude)*	Upper level	460 - 470 m.
		Lower level	400 - 460 m.
II	ABURATARUGA TERRACE *(420 m. altitude)*	Uzuranfauro level	370 - 420 m.
		Aburataruga level	300 - 380 m.
		Asrosariya level	240 - 300 m.
		Asyakeros level	220 - 260 m.
III	SHINAPARU TERRACE *(200 m. altitude)*		140 - 200 m.
IV	LUGI TERRACE *(150 m. altitude)*	Lugi level	100 - 150 m.
		Benakan level	60 - 100 m.
V	TARAGAJA TERRACE *(60 m. altitude)*	Taragaja level	20 - 60 m.
		Teruson level	20 m.

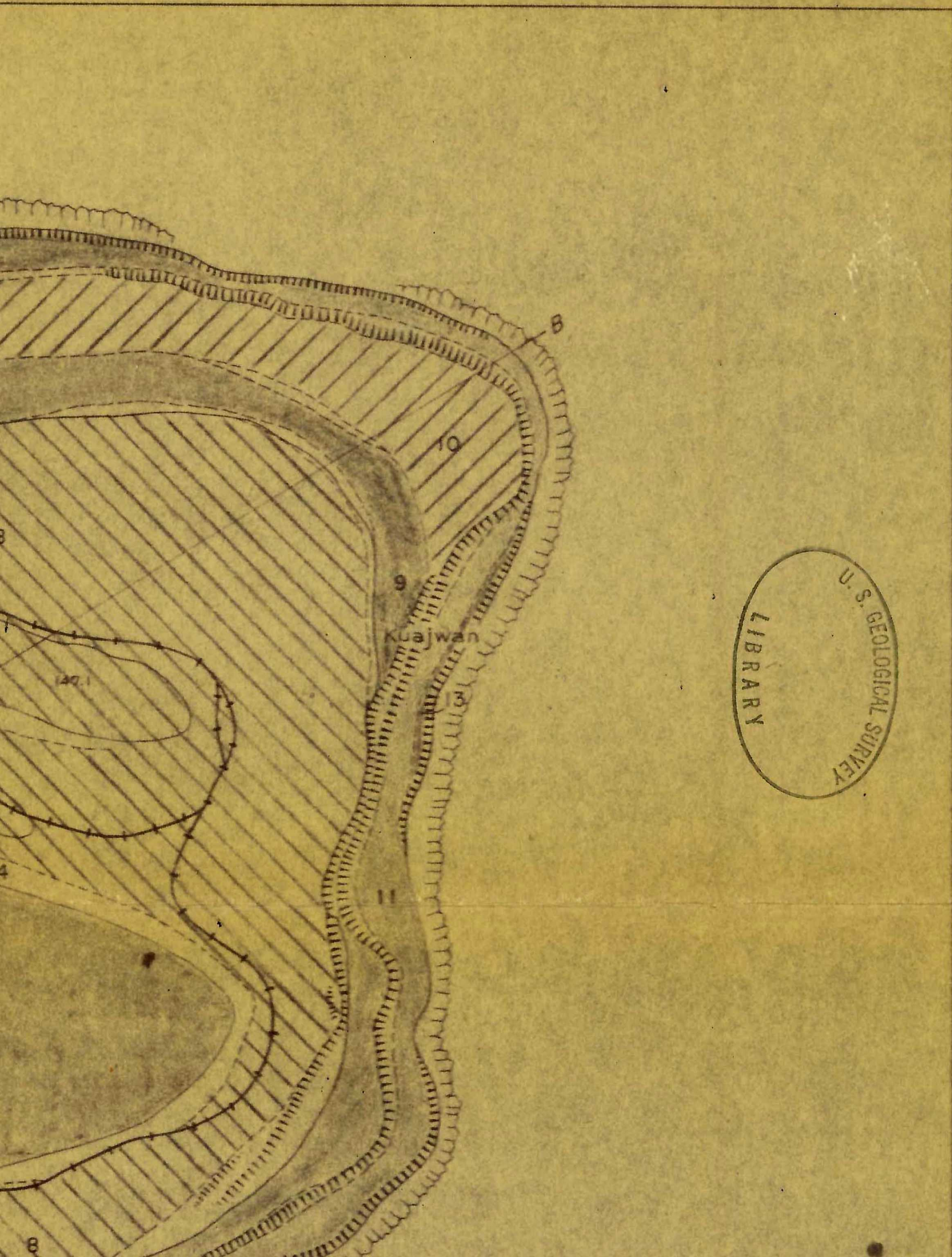

MAP O
RO
S
1
2
3 360-390 m.
4 300-360 m.
280-300 m.
Iisan
6
7
8
9
10
11
N
1 0 1 2 KM.
Scale 1 : 24,000
G
13
Tatacho
10

OF TERRACES
ON
OTA ISLAND
1934

by
ho SUGAWARA




13
12
Mochon
13
11
10
11
9
9
8
Lugi
181.8
7
170.8
Shinaparu


B
10
9
Kuajwan
13
11
8

VI	MIRIKATTAN TERRACE	Sonson level	5 m.
		Mirikattan level	4 m.

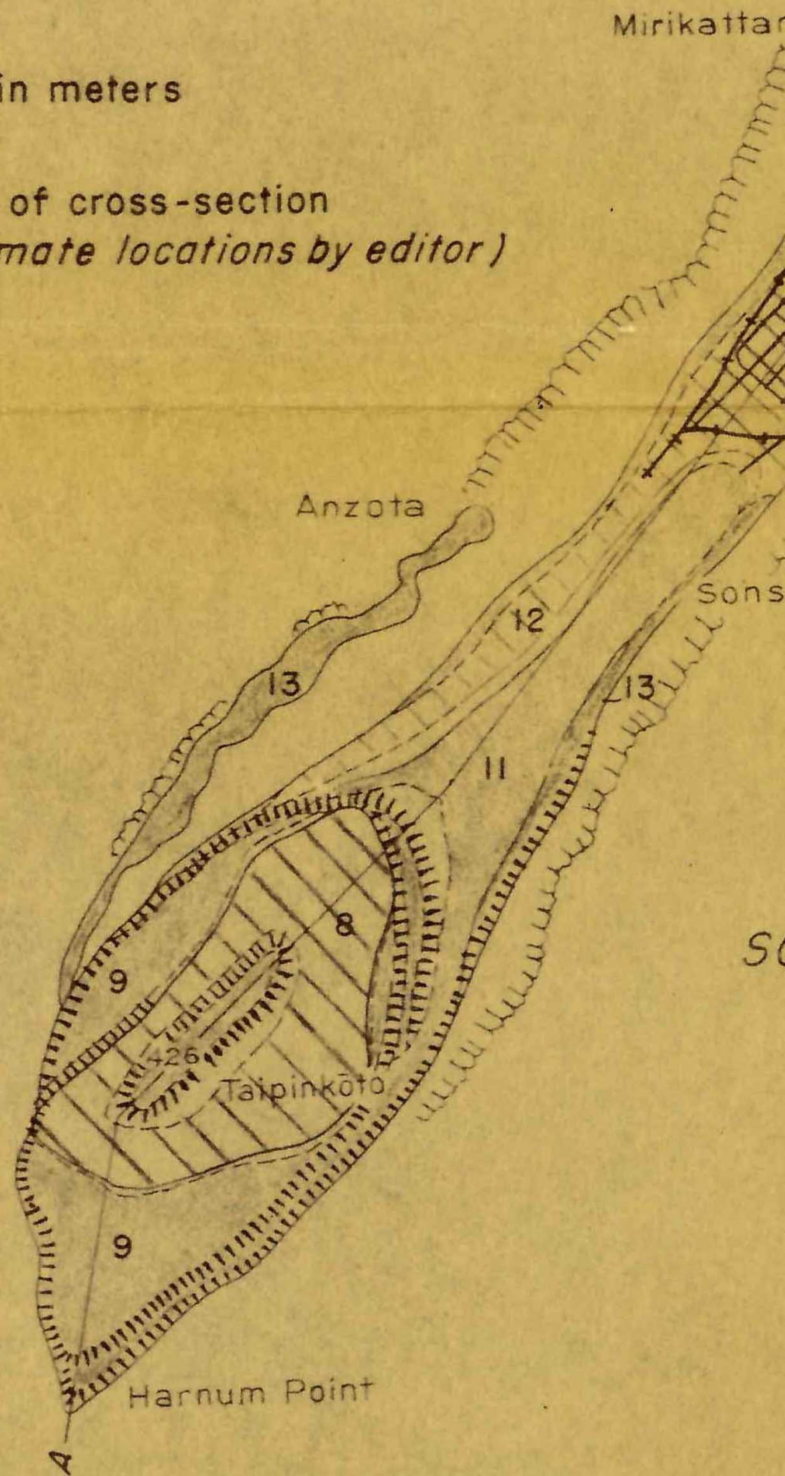
Precipice and fault scarp

Reefs

Aerial cableway

170.8 Altitude in meters

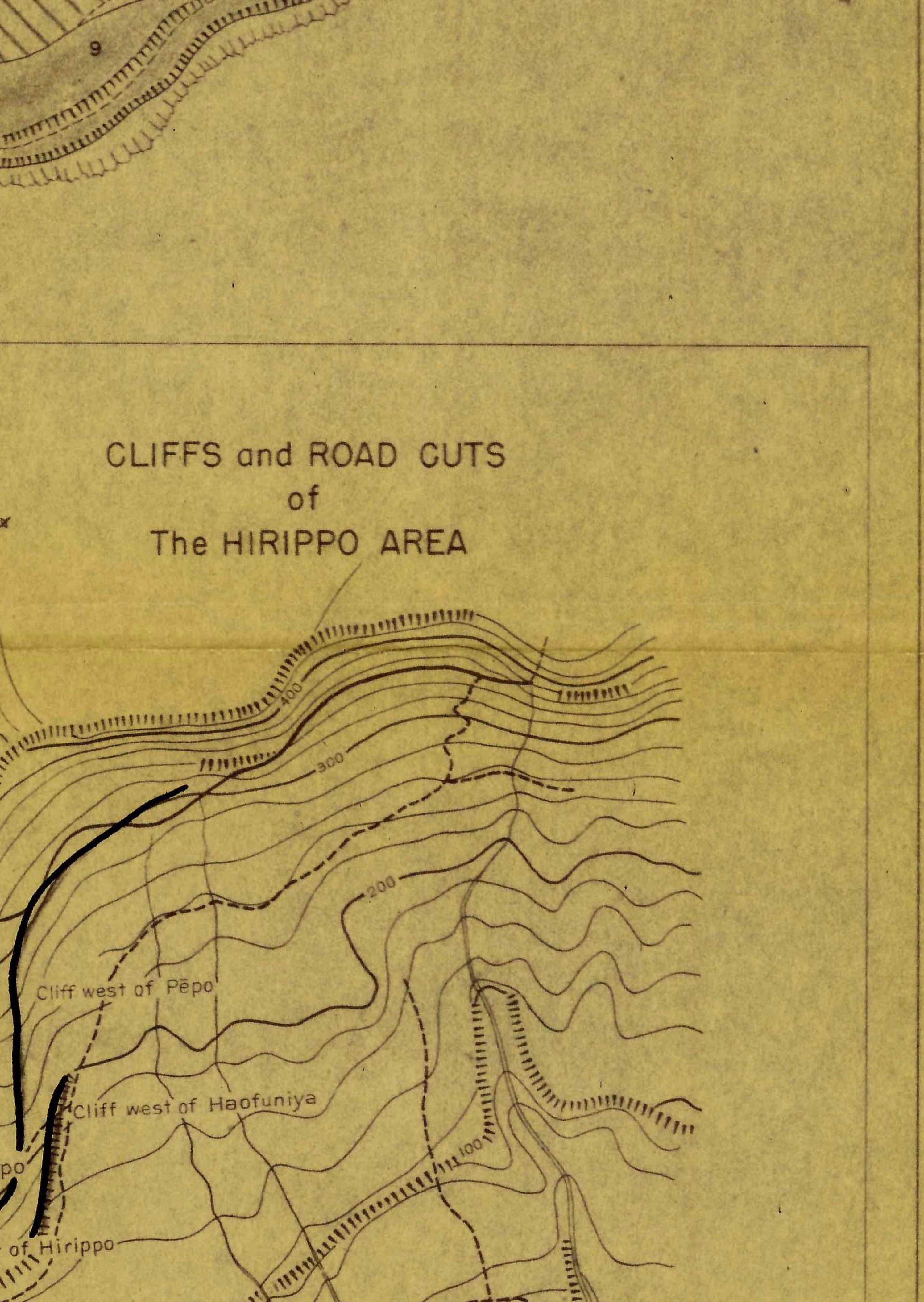
A —— B Location of cross-section
(Approximate locations by editor)



12
13
Finadēpo
9
m
Siyasaja
8
Fusudorina
14
9
Abu
7
Rasgya
Asyakeros
5
Hirosu
Iisan Hill
6
COCOA Co.
13
D
1
4
3
470.5
8
14
Aan
14
Benakan
5
11
14
9
7
Rimpanai
L
3
OSANJAYA - WAN (BAY)
Teruson
5
6
Hirippo
7
8
14
Taihanom
10

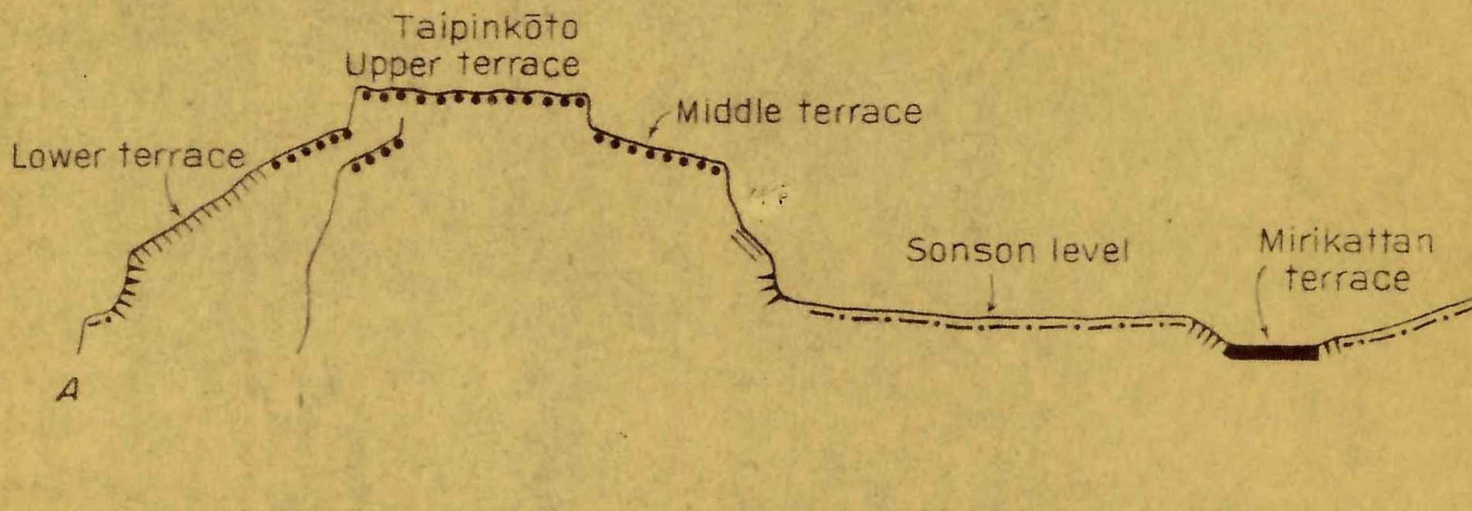
14
14
Chego
4
Uzuranfauro
3
yaccot
5
Asrosadya
4
Aburatanga
Asfantango
496.4
Mt. Manila
475.0
Sabana
1
2
7
Parie
400
300
Spring
14
200
14
7
100
9
8
Mariiru
Taragaja
10
12
14
10
12
Aueniya
13
I

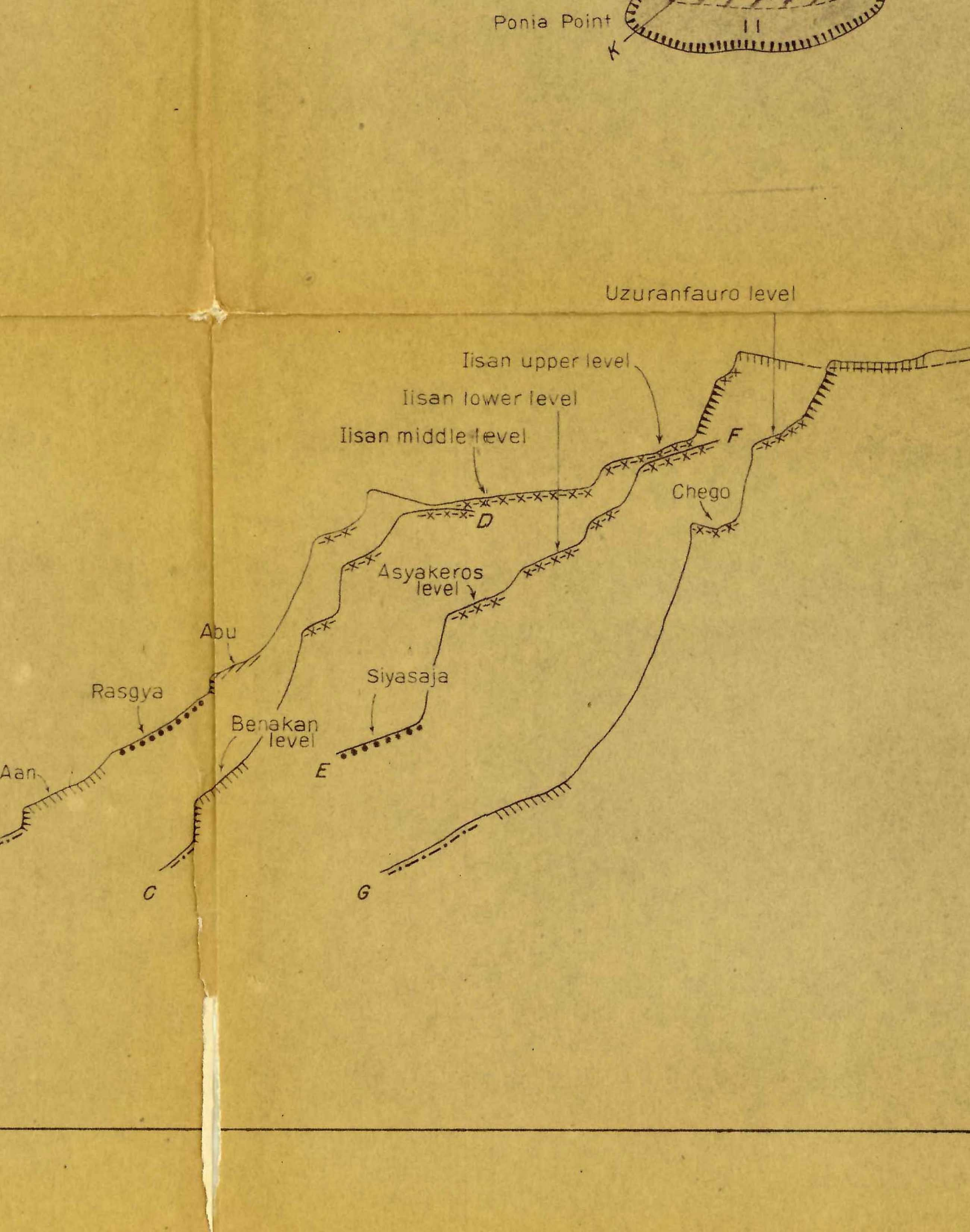

7
8
11
Aragen
Pashyahai
8
11
400
300
200
100
Teruson cut
Gagane cut
Cliff east of Hirip
Cliff west
N


9
CLIFFS and ROAD CUTS
of
The HIRIPPO AREA
400
300
200
100
Cliff west of Pēpo
Cliff west of Haofuniya
of Hirippo

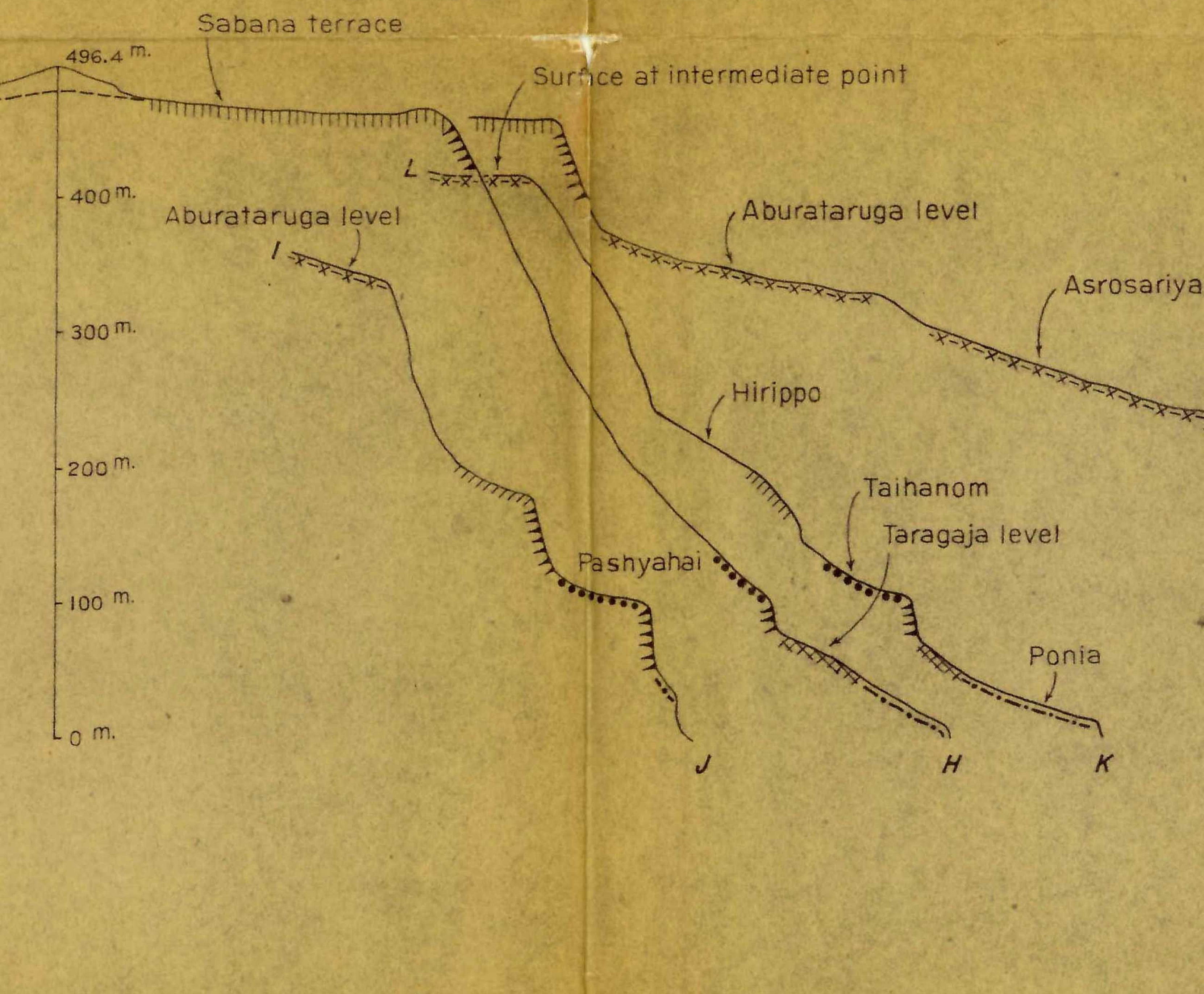
CROSS-SECTION of TERRACES

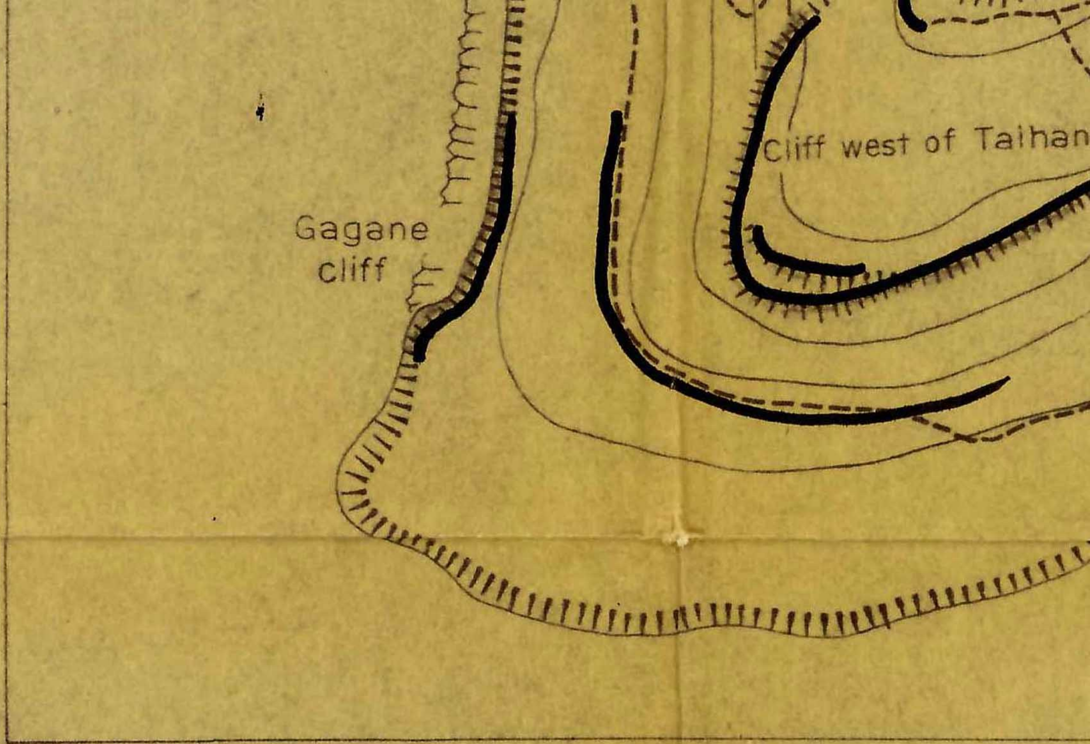
Horizontal-scale 1 : 24,000



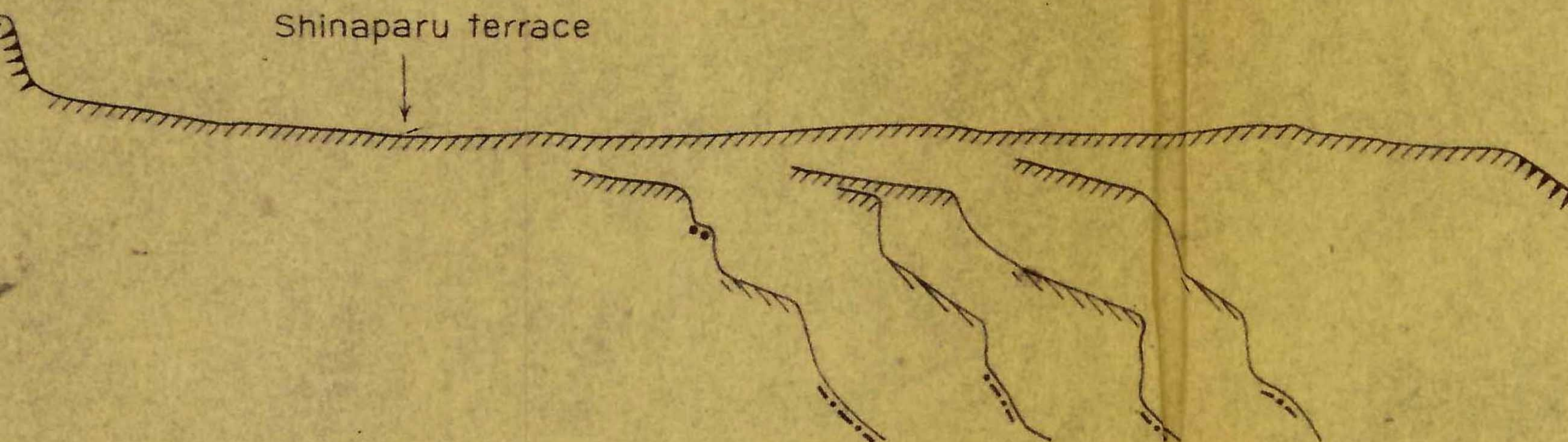


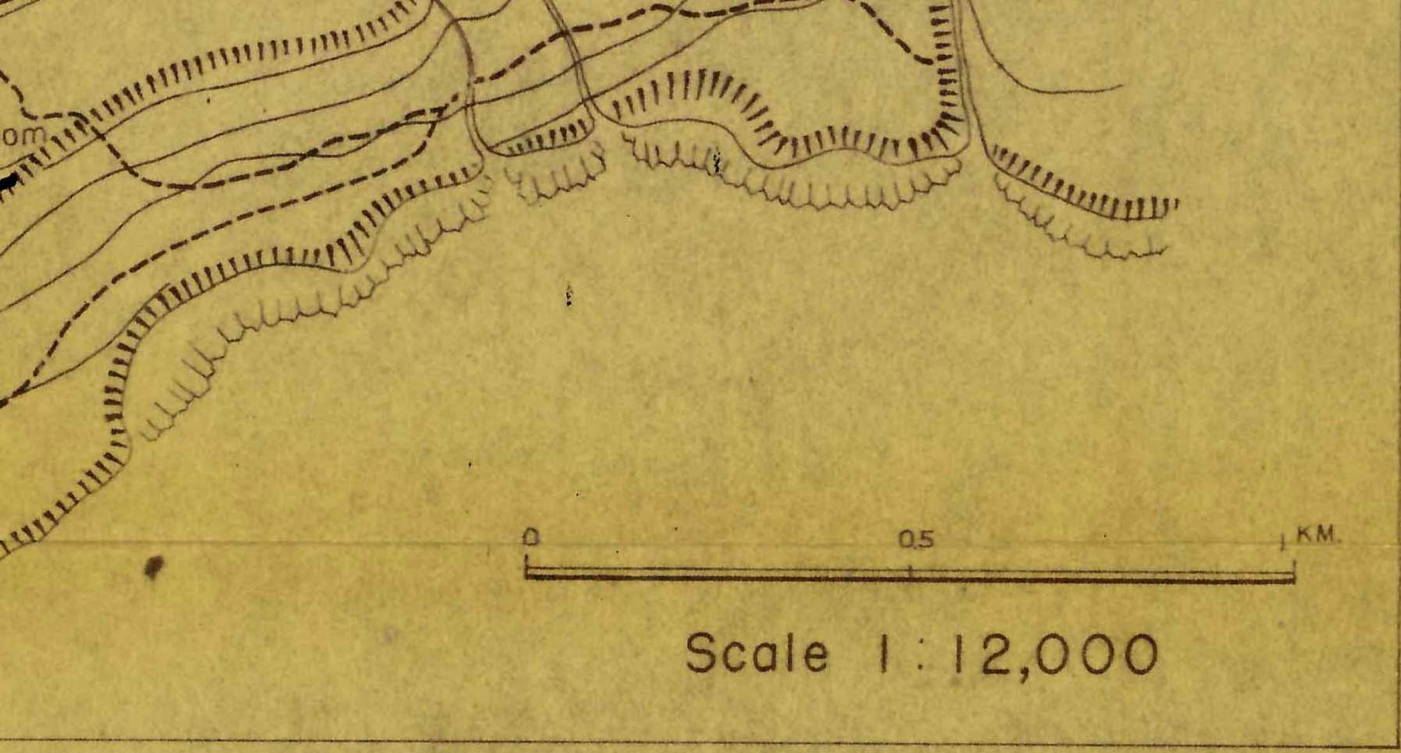
Ponia Point
K
II
Uzuranfauro level
Iisan upper level
Iisan lower level
Iisan middle level
F
D
Chego
Asyakeros
level
Abu
Rasgya
Siyasaja
Benakan
level
Aan
E
C
G

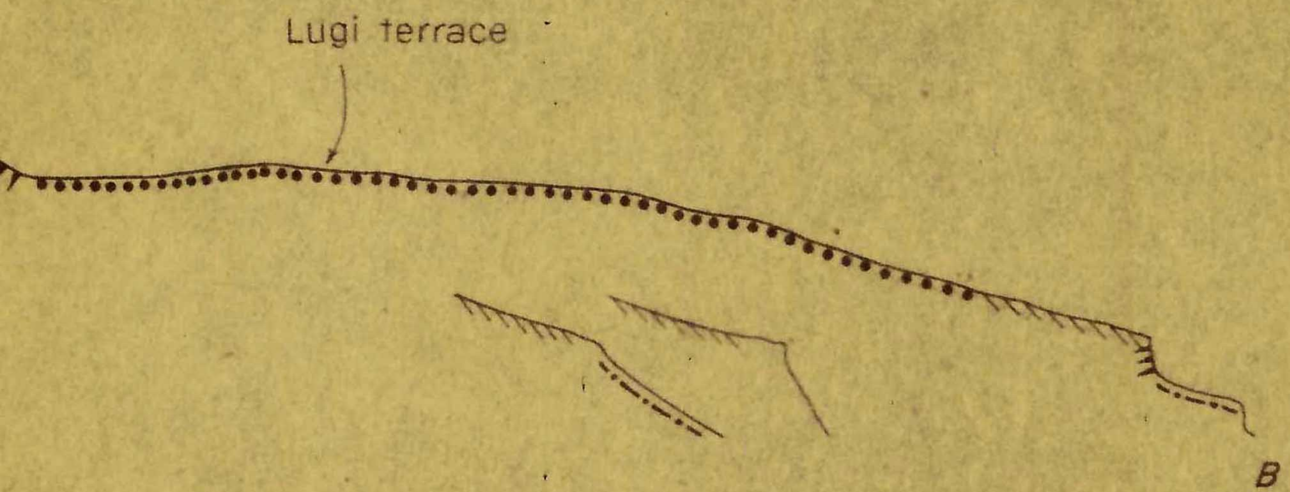

Sabana terrace
496.4 m.
Surface at intermediate point
L
400 m.
Aburataruga level
I
Aburataruga level
Asrosariya
300 m.
Hirippo
200 m.
Taihanom
Taragaja level
Pashyahai
100 m.
Ponia
0 m.
J
H
K

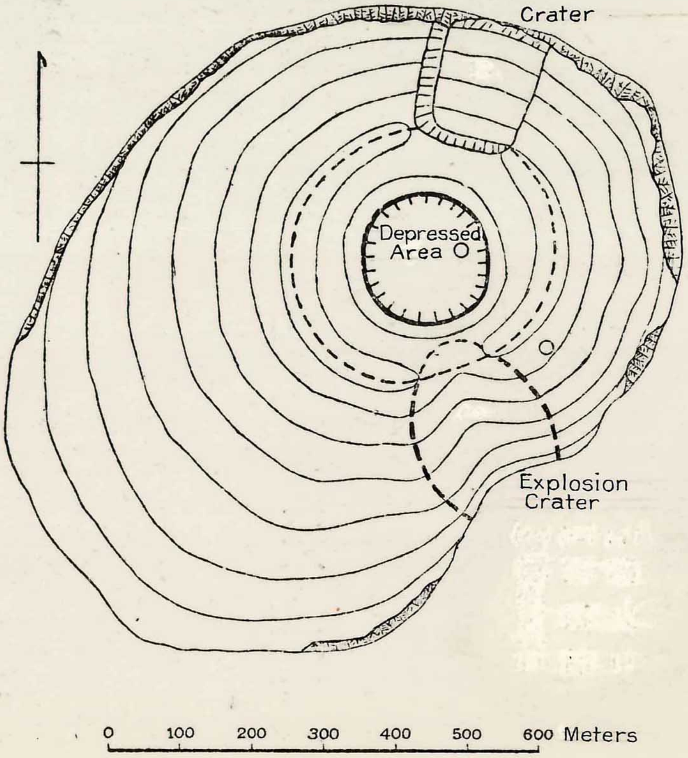


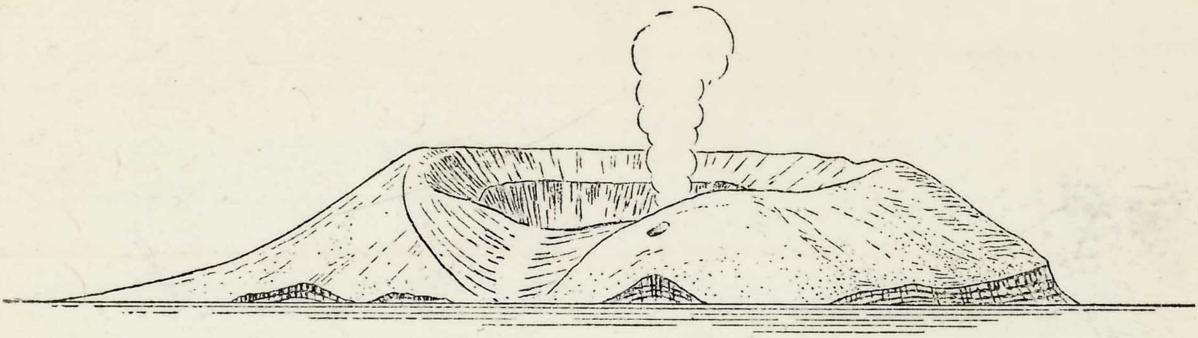
level



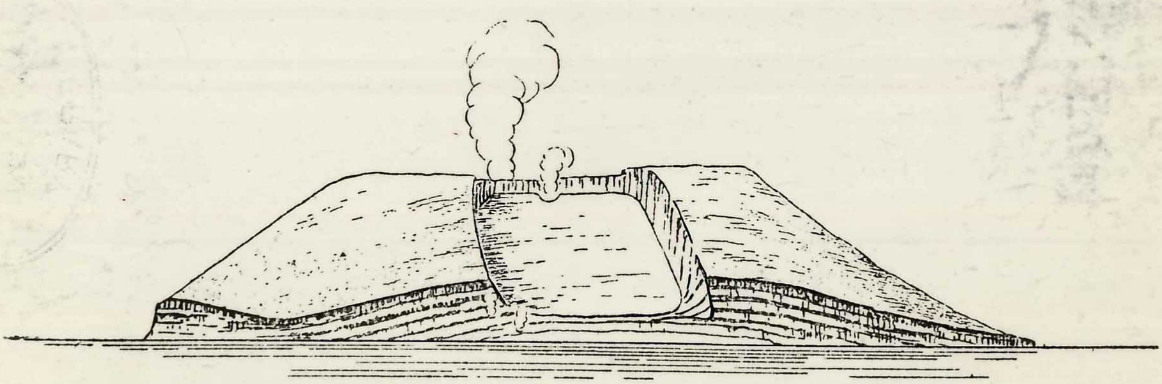

om
0
0.5
1 KM.
Scale 1:12,000


Lugi terrace
B

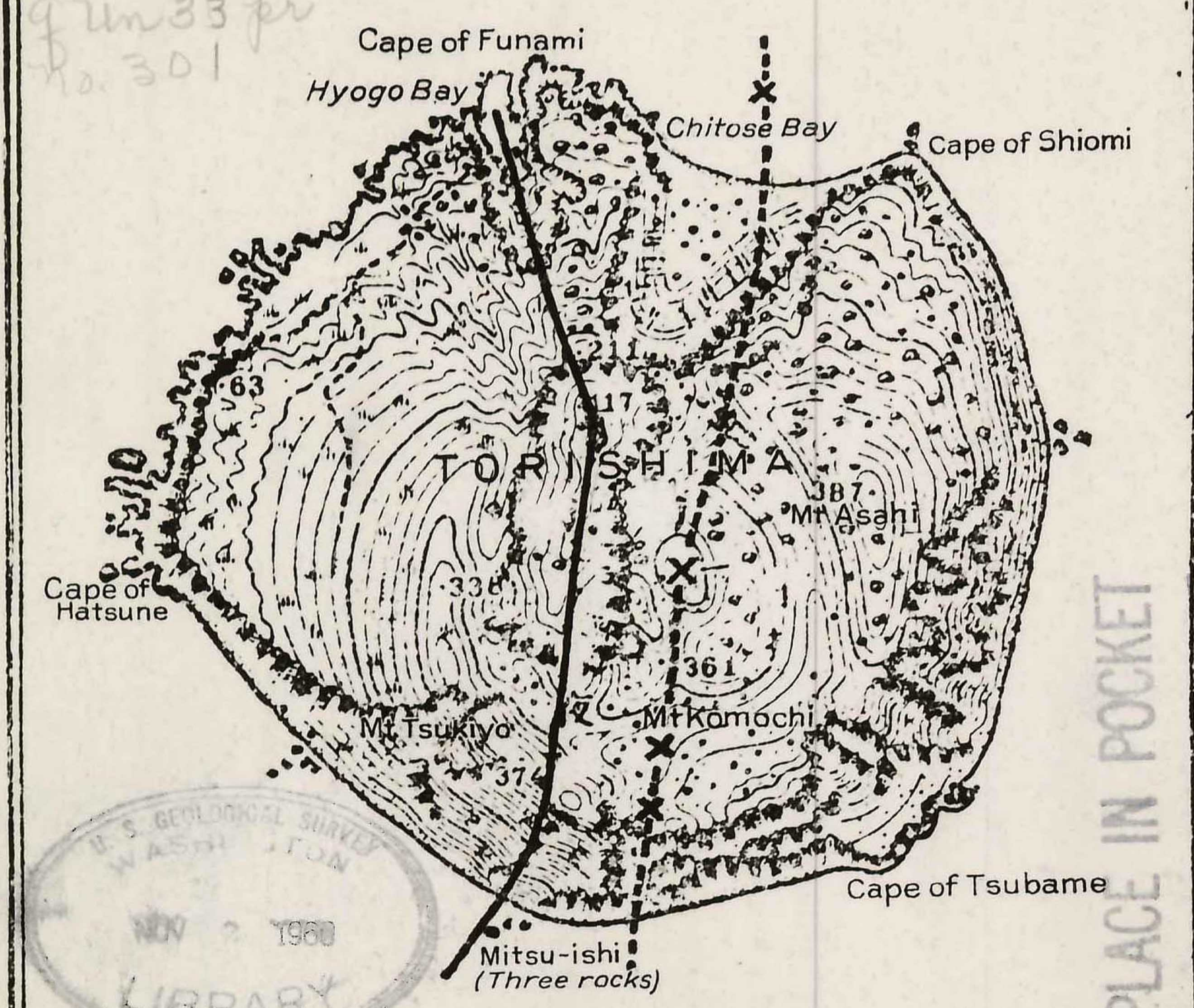




The newly born island seen from the southeast

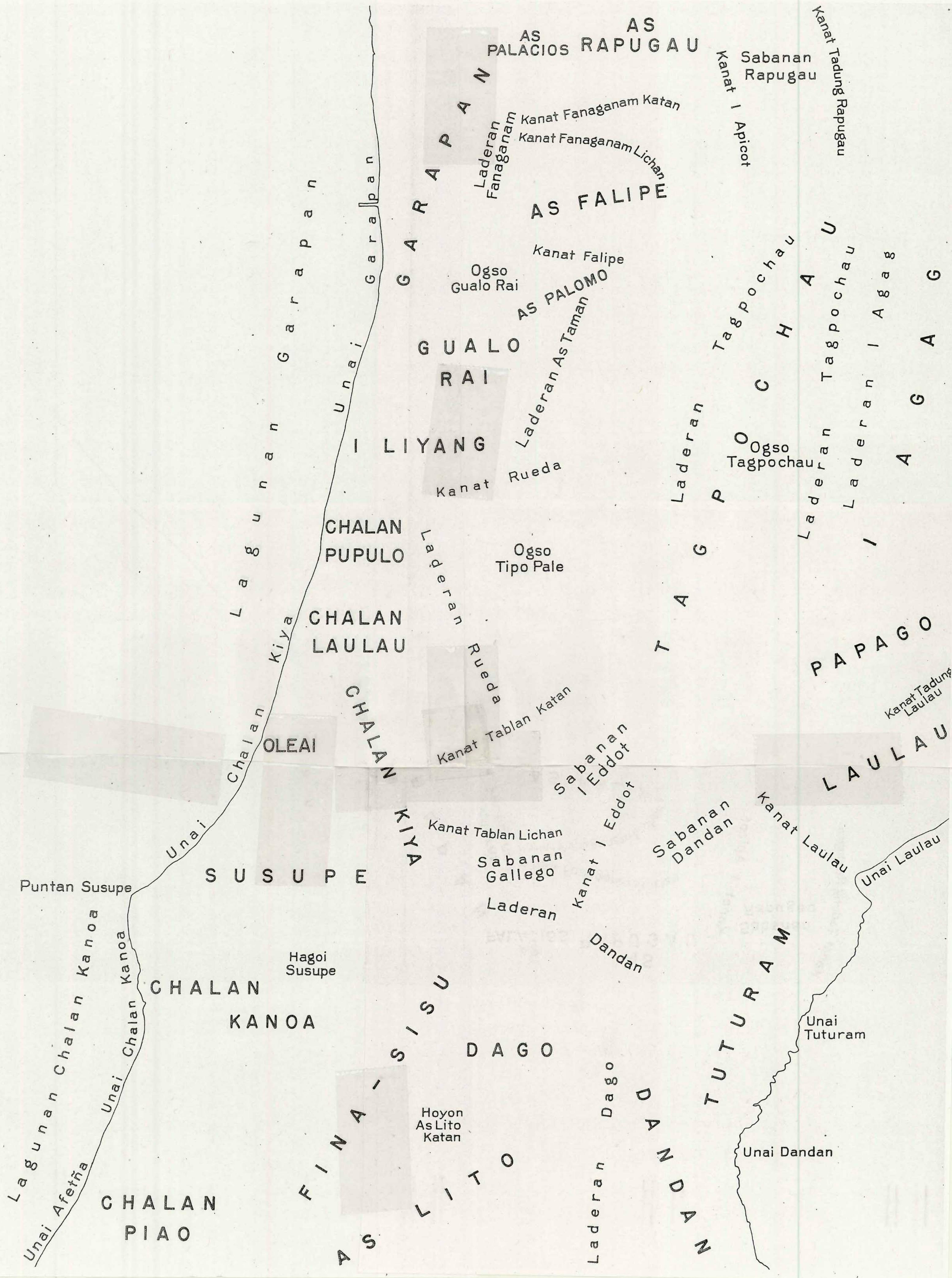


The newly born island seen from the north



X Former crater
- - - - - Line connecting the former craters
——— Line on which the explosion in 1902 occurred

500 0 1000 Meters



(PRELIMINARY)

NATIVE GEOGRAPHIC NAMES FOR SAIPAN

Compiled by P.E.Cloud Jr., U.S.Geological Survey, January 1949 from native sources

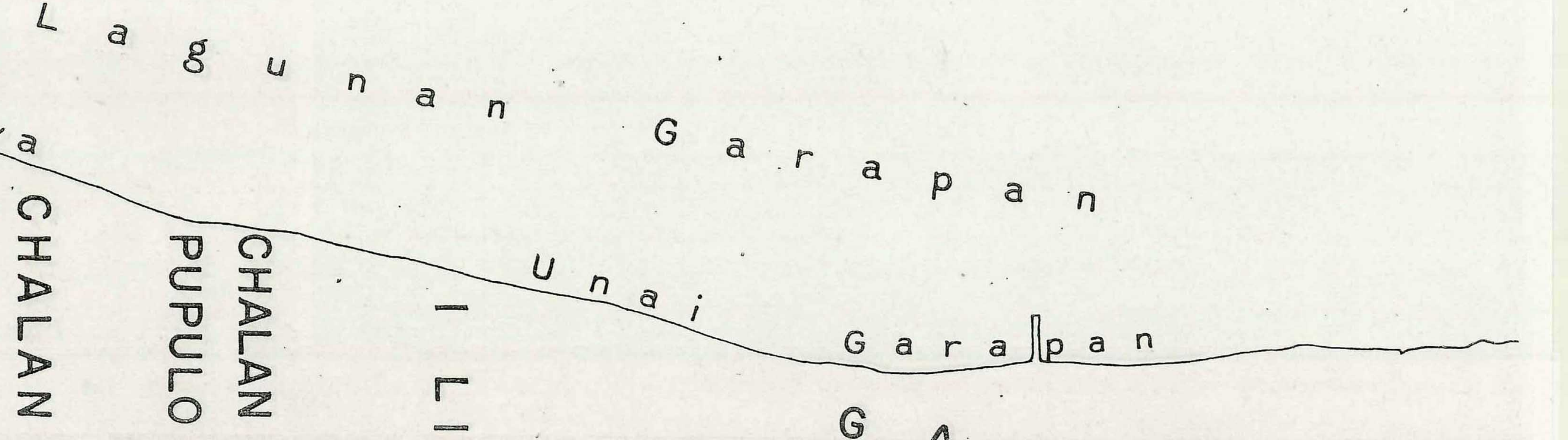
English meanings of key words

As - the place of
Bahia - bay
Bobo - spring
Dangkulo - big
Dikiki - little
Hagoi - lake
Hoyon (Hozon) - large sink
I - the
Isleta - small island
Kanat - ravine
Katan - north
Laderan - cliffs
Laguna - lagoon
Luchan - south
Liyang (Lizang) - cave
Ogso - mountain, hill or ridge
Puetton - harbor
Puntan - point
Sabanan - natural grassland
Sadog - a ravine in which fresh water occurs
Unai - beach (literally sand)

See Gazetteer of Geographic Names for Saipan for full translations of names, alternate names, and essential rules of grammar and enunciation as applied to Chamorro words here used.

Names given in capital letters are of major areal signifance (land-districts of a sort). Others are here given in lower-case, upright letters, whether hypsographic, topographic, or otherwise.

Prepared by Geological Surveys Branch
Intelligence Division, Office of the Engineer
General Headquarters, Far East Command



Lagunan Garapan
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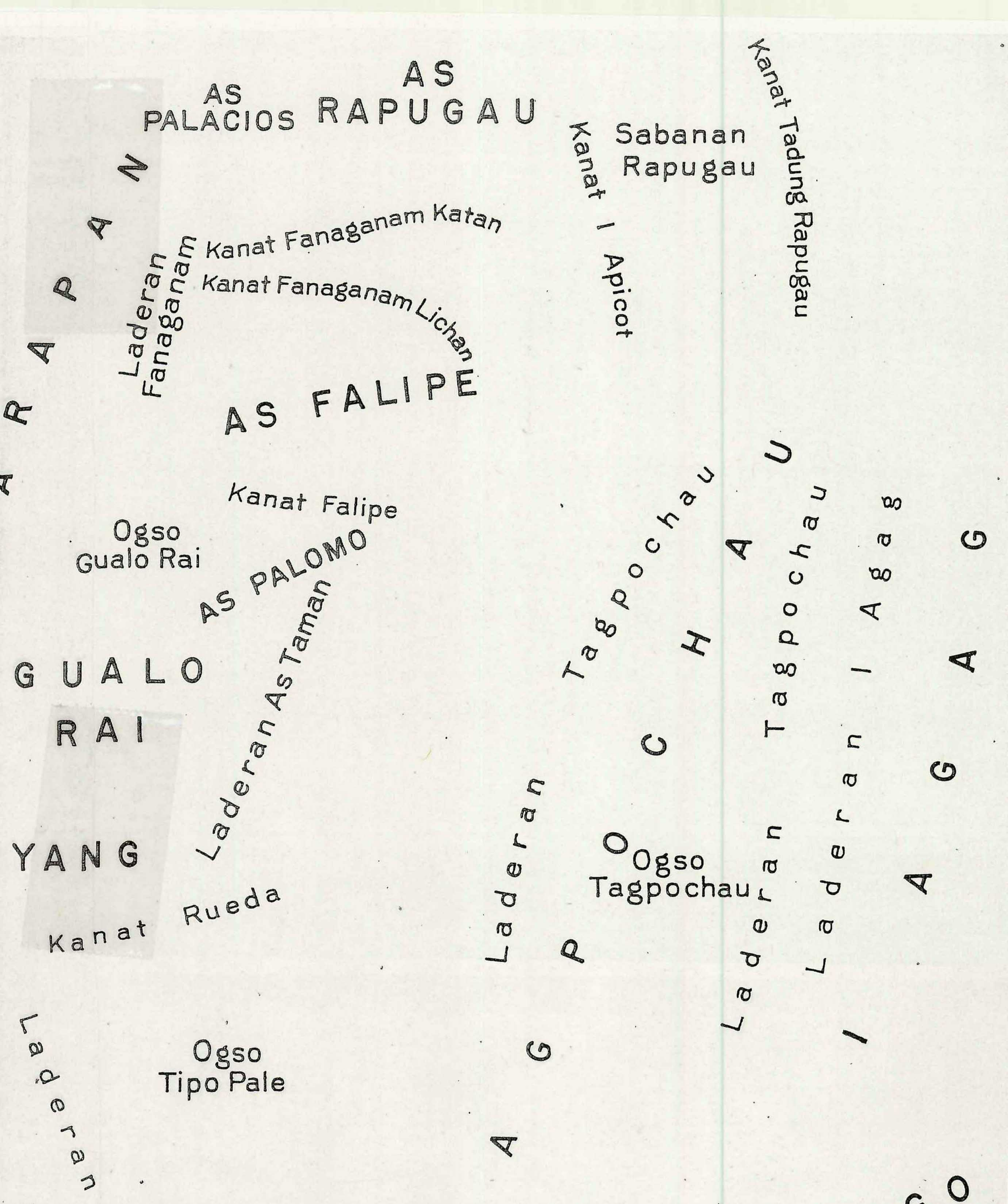
AS PALACIOS
AS RAPUGAU
Sabanan Rapugau
Kanat I Apicot
Kanat Tadung Rapugau
ARAPAN
Kanat Fanaganam Katan
Kanat Fanaganam Lichan
Laderan Fanaganam
AS FALIPE
Kanat Falipe
Ogso Gualo Rai
AS PALOMO
Laderan As Taman
GUALO RAI
YANG
Kanat Rueda
Laderan
Ogso Tipo Pale
Laderan
AGPOCHAU
Tagpochau
Ogso Tagpochau
Laderan Tagpochau
Laderan I Agag
I AGAG
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(PRELIMINARY)

NATIVE GEOGRAPHIC NAMES FOR SAIPA

Compiled by P.E.Cloud Jr., U.S. Geological Survey, January 1949 from native s

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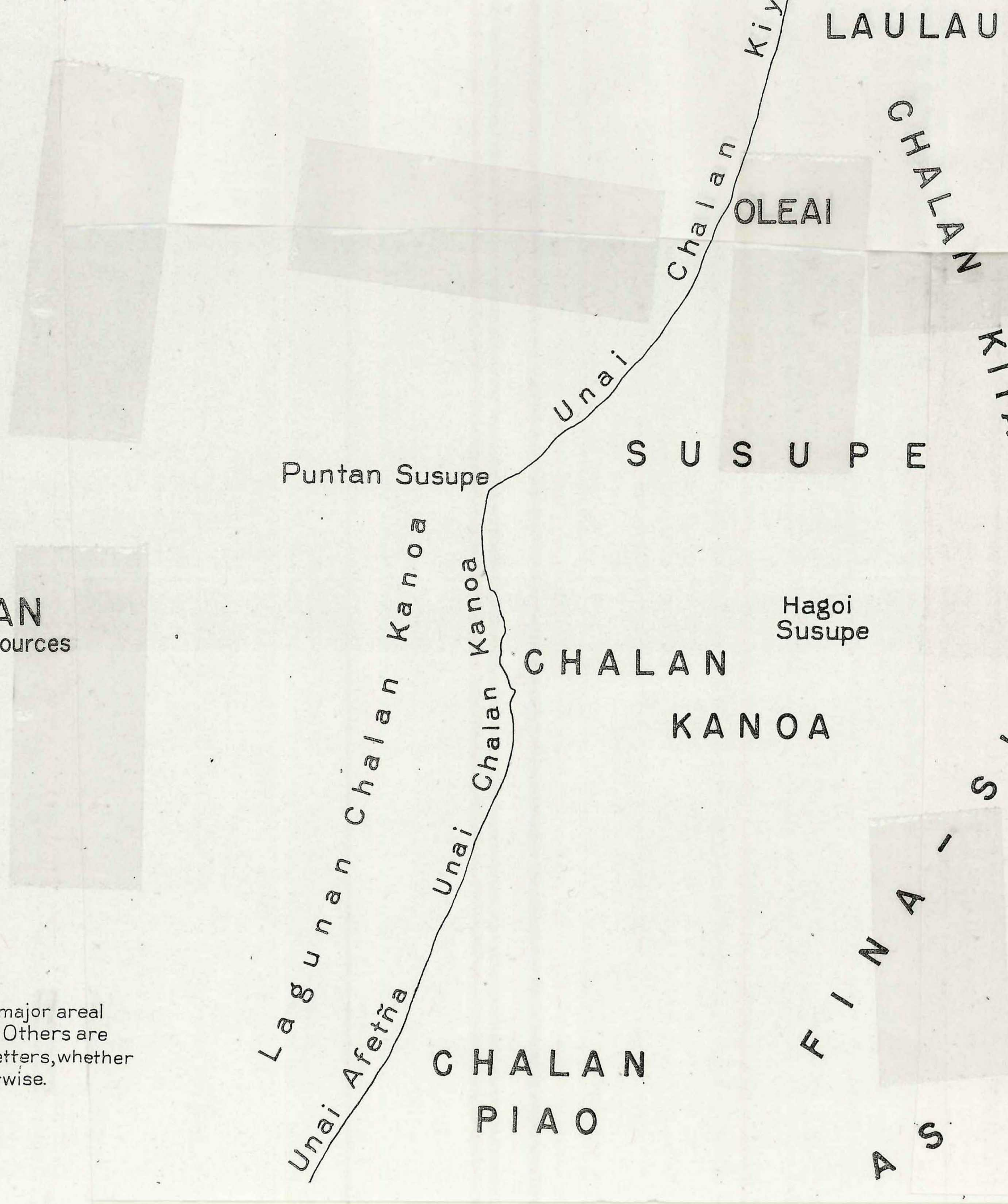

LAULAU
Unai Chalan Kiy
OLEAI
CHALAN KI
SUSUPE
Puntan Susupe
Unai Chalan Kanoa
Lagunan Chalan Kanoa
Hagoi Susupe
CHALAN KANOA
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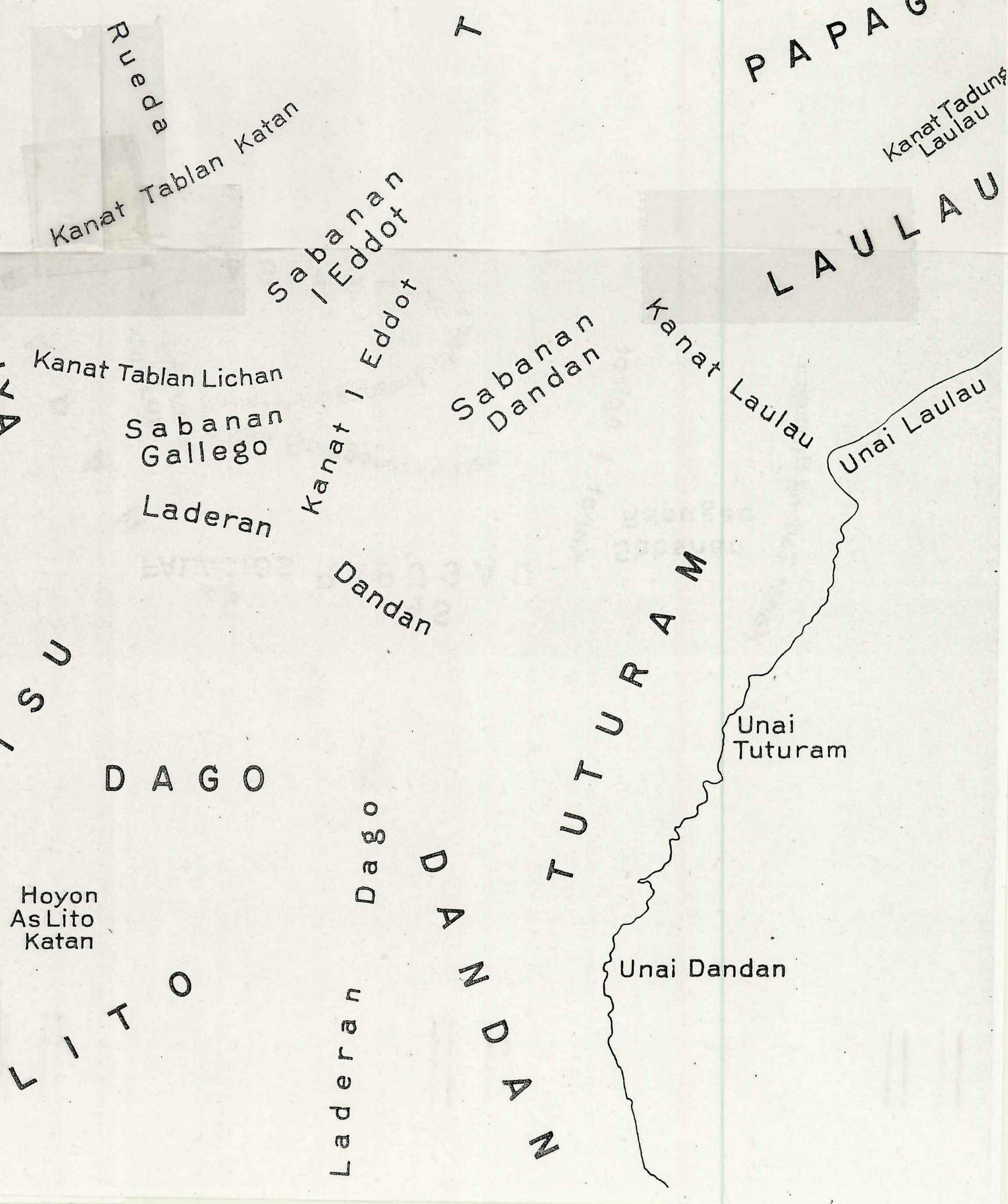
Rueda
Kanat Tablan Katan
LAULAU
Sabanan
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Kanat I Eddot
Sabanan
Dandan
Kanat Laulau
Unai Laulau
Kanat Tablan Lichan
Sabanan
Gallego
Laderan
Dandan
TUTURAM
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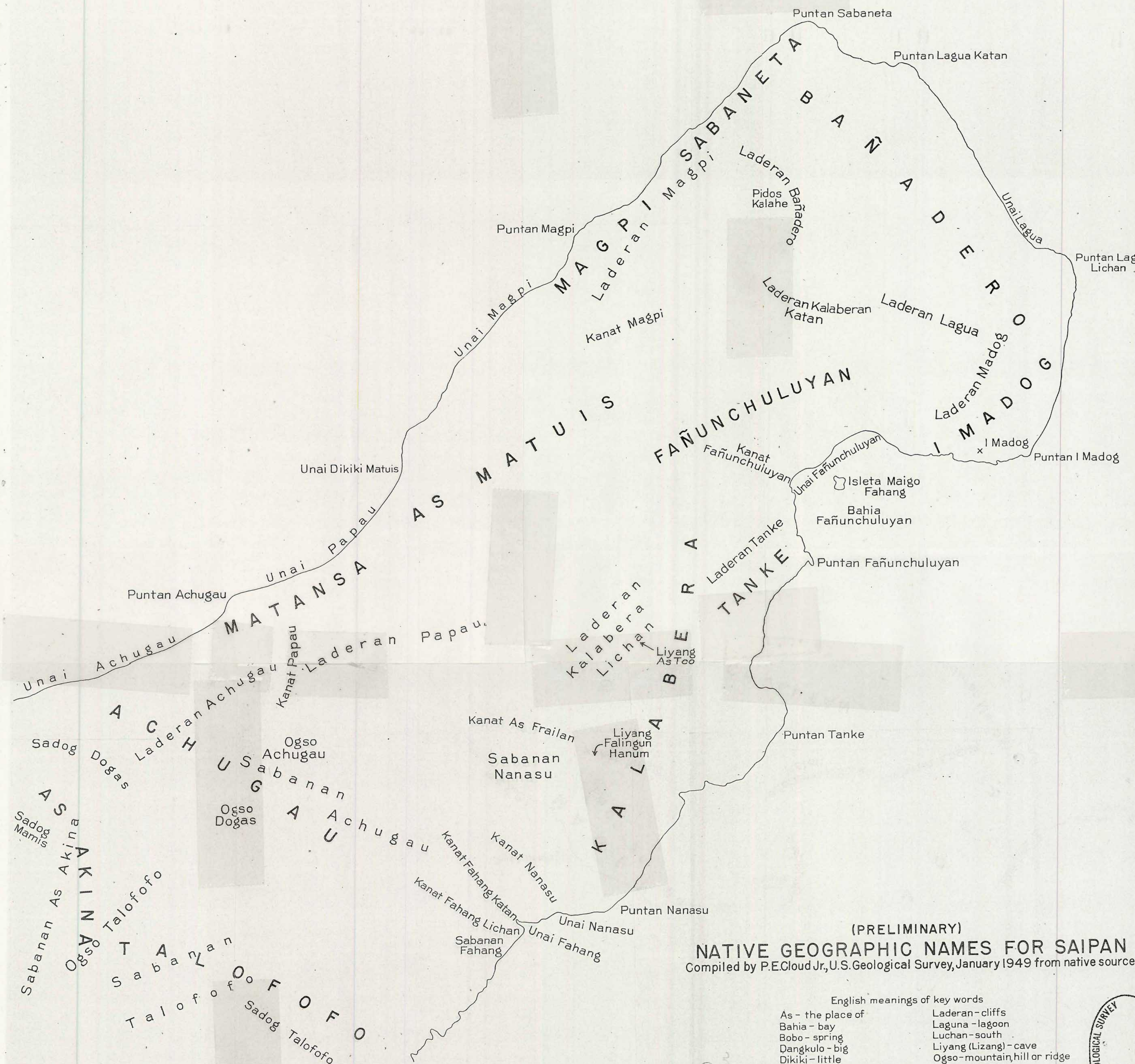

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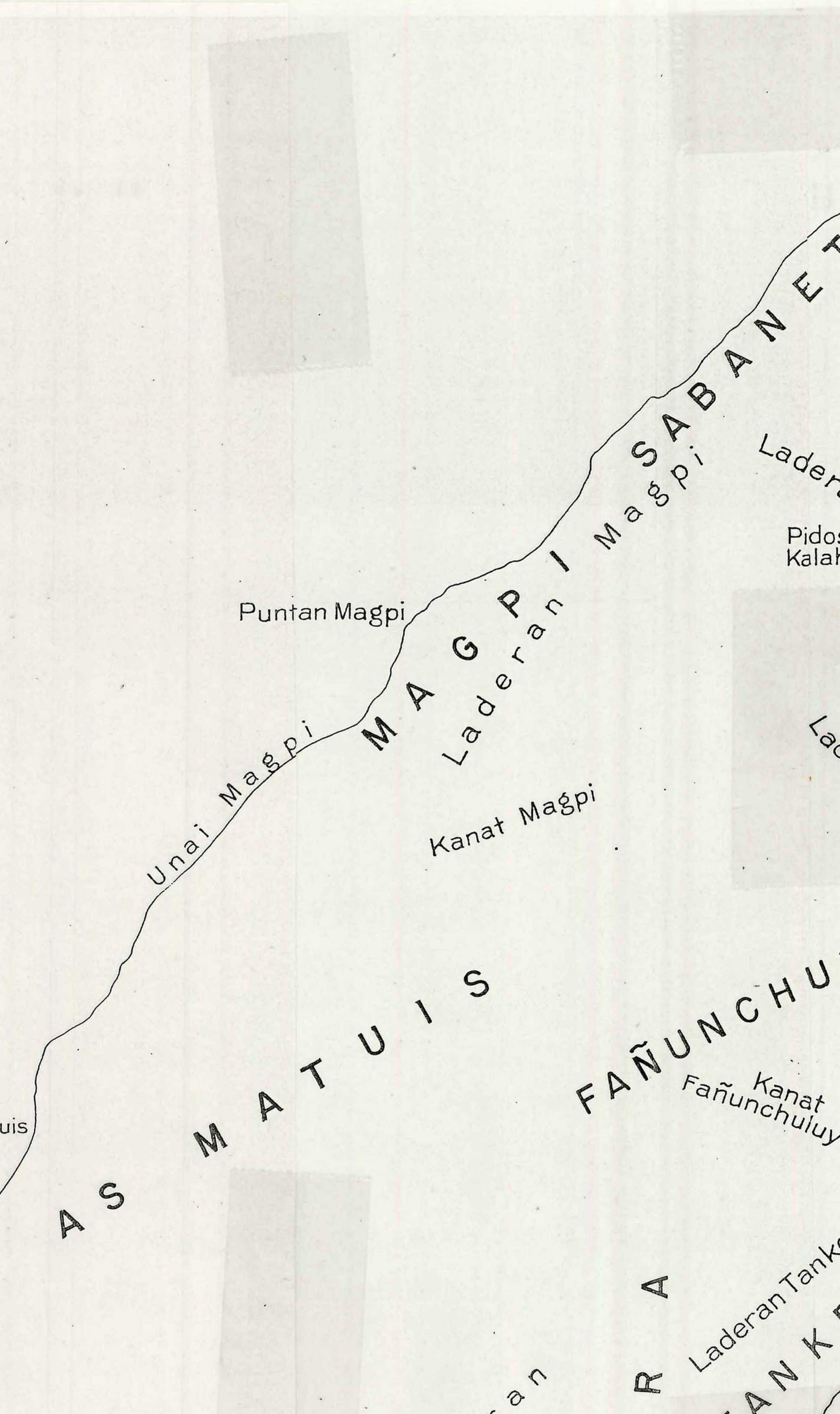
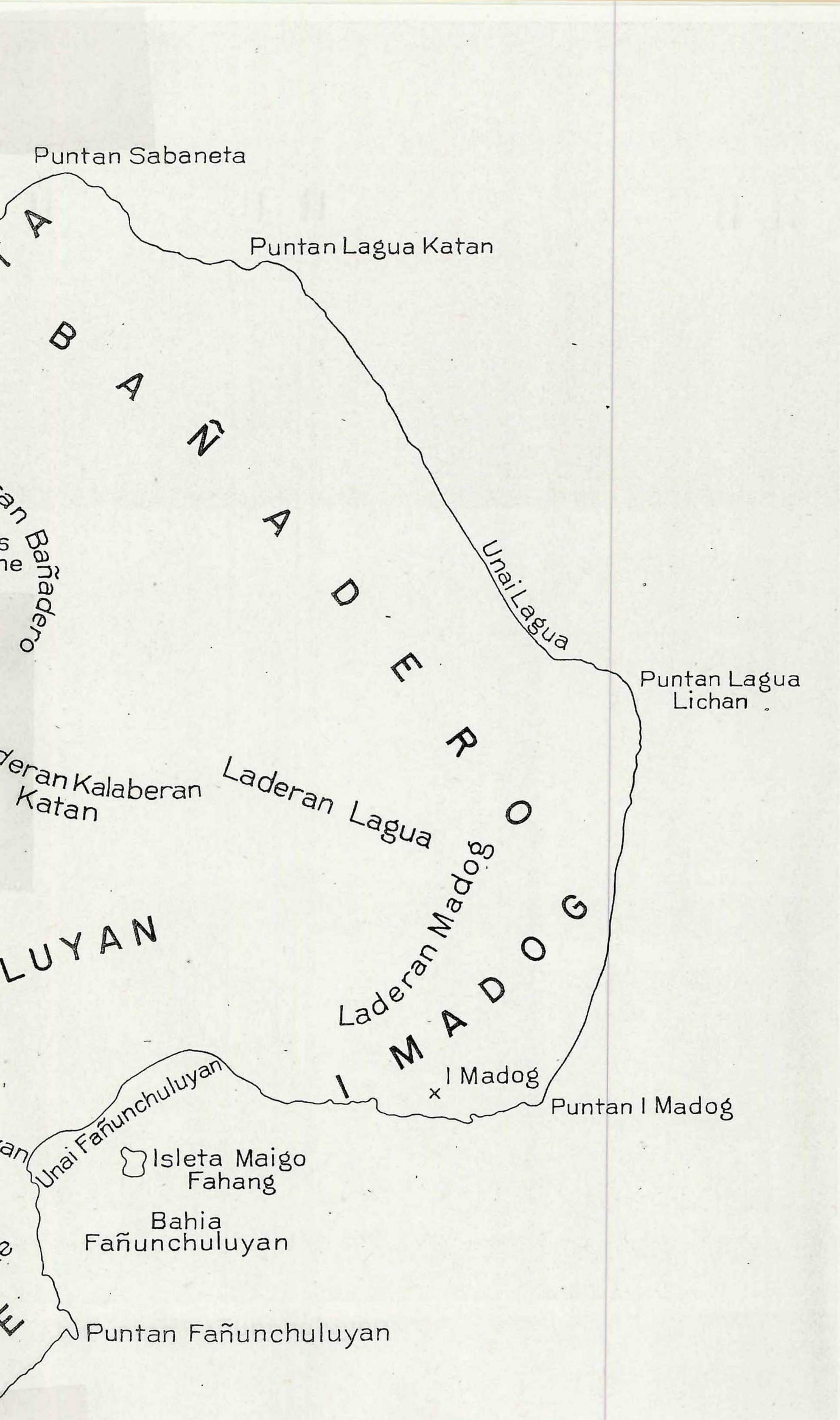
Unai Dikiki Mat
Unai Papau
ANSA
Puntan Achugau



Puntan Magpi
MAGPI
Laderan Magpi
Unai Magpi
Kanat Magpi
MATUIS



Puntan Sabaneta
Puntan Lagua Katan
BAÑADERO
Bañadero
Unai Lagua
Puntan Lagua Lichan
Kalaberan Katan
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Laderan Madog
LUYAN
I MADOG
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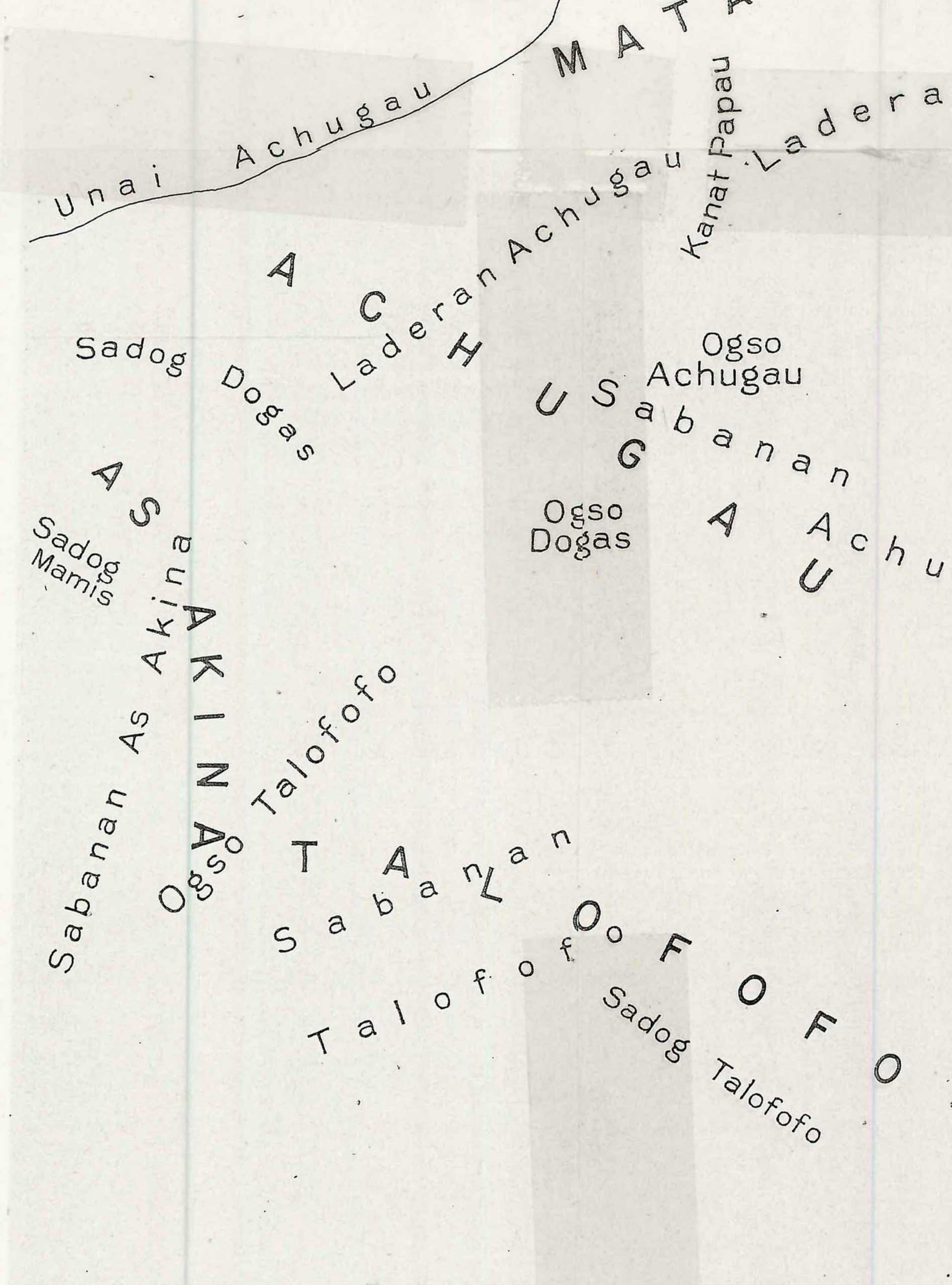
Puntan I Madog
Unai Fañunchuluyan
Isleta Maigo Fahang
Bahia Fañunchuluyan
Puntan Fañunchuluyan


MATA
Unai Achugau
Laderan Achugau
Kanat Papau
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ACHUGAU
Sadog Dogas
Ogso Achugau
Sabanan Achu
Ogso Dogas
AS AKINA
Sadog Mamis
As Akina
Sabanan As Akina
Ogso Talofofo
Ogso
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Sabanan
Talofofo
Sadog Talofofo

n Papau
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Kanat Nanasu
Kanat Fahang Katan
Kanat Fahang Lichan
Puntan Nanasu
Unai Nanasu
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Sabanan Fahang
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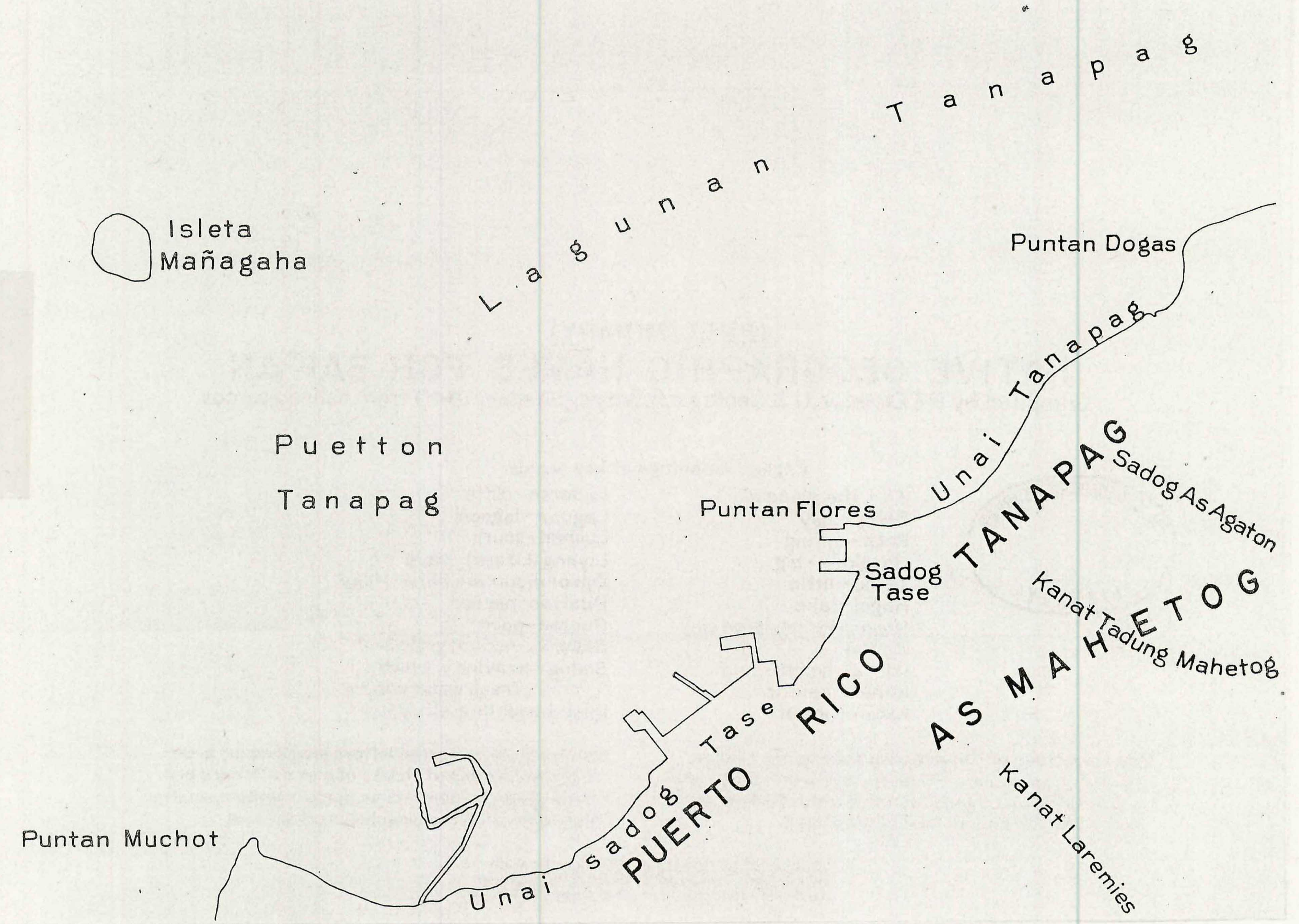

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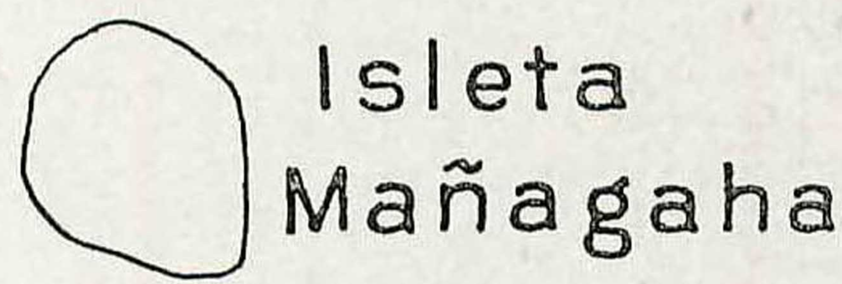

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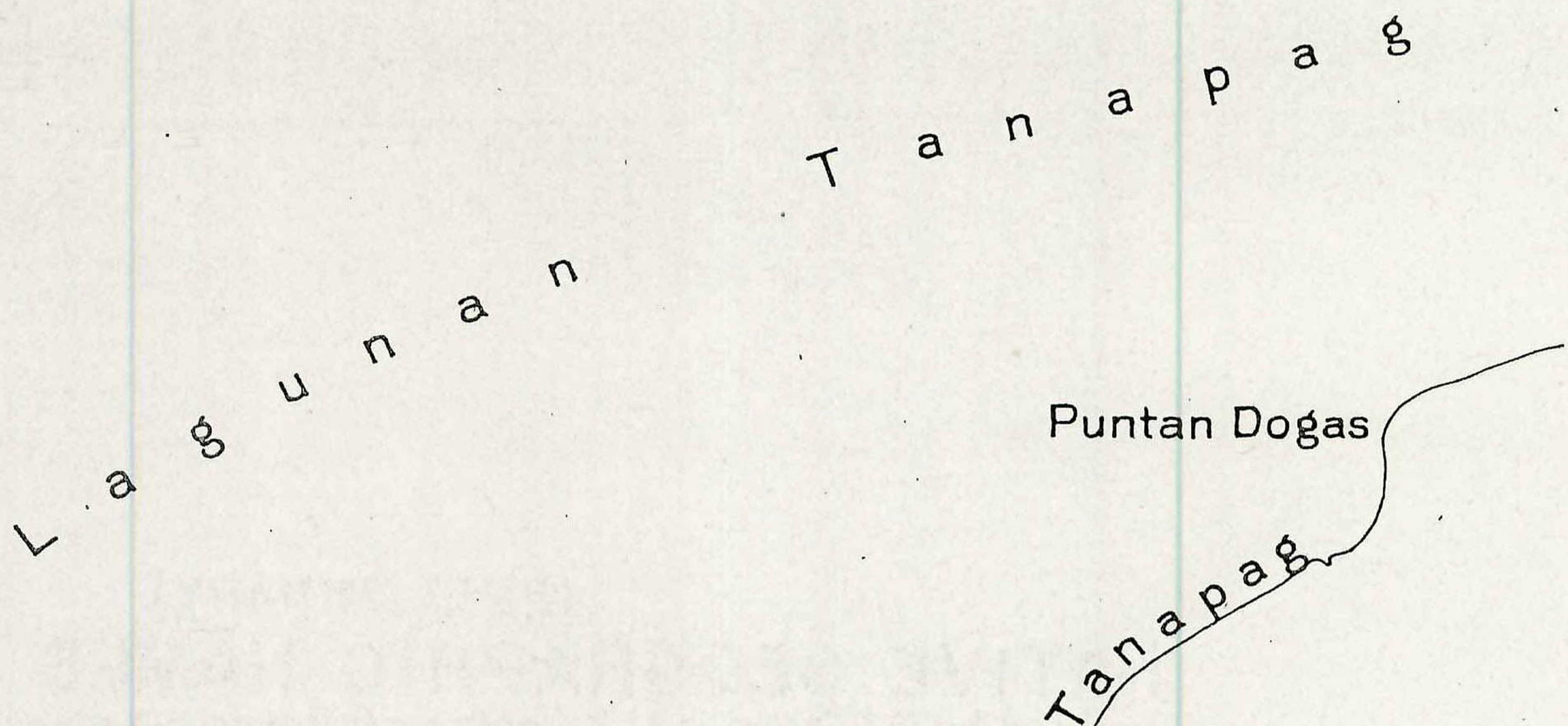
Lagunan Tanapag
Puntan Dogas
Tanapag

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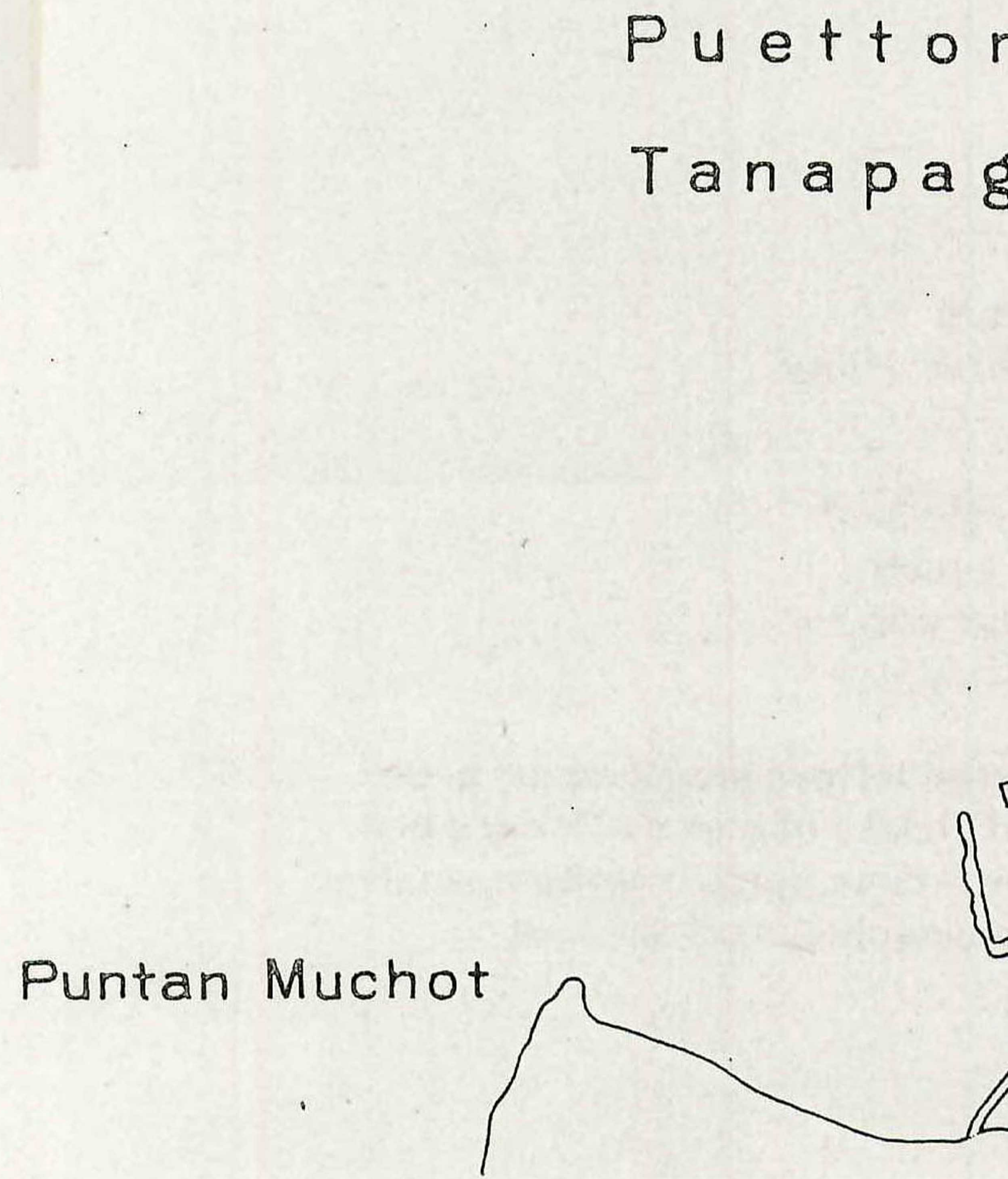

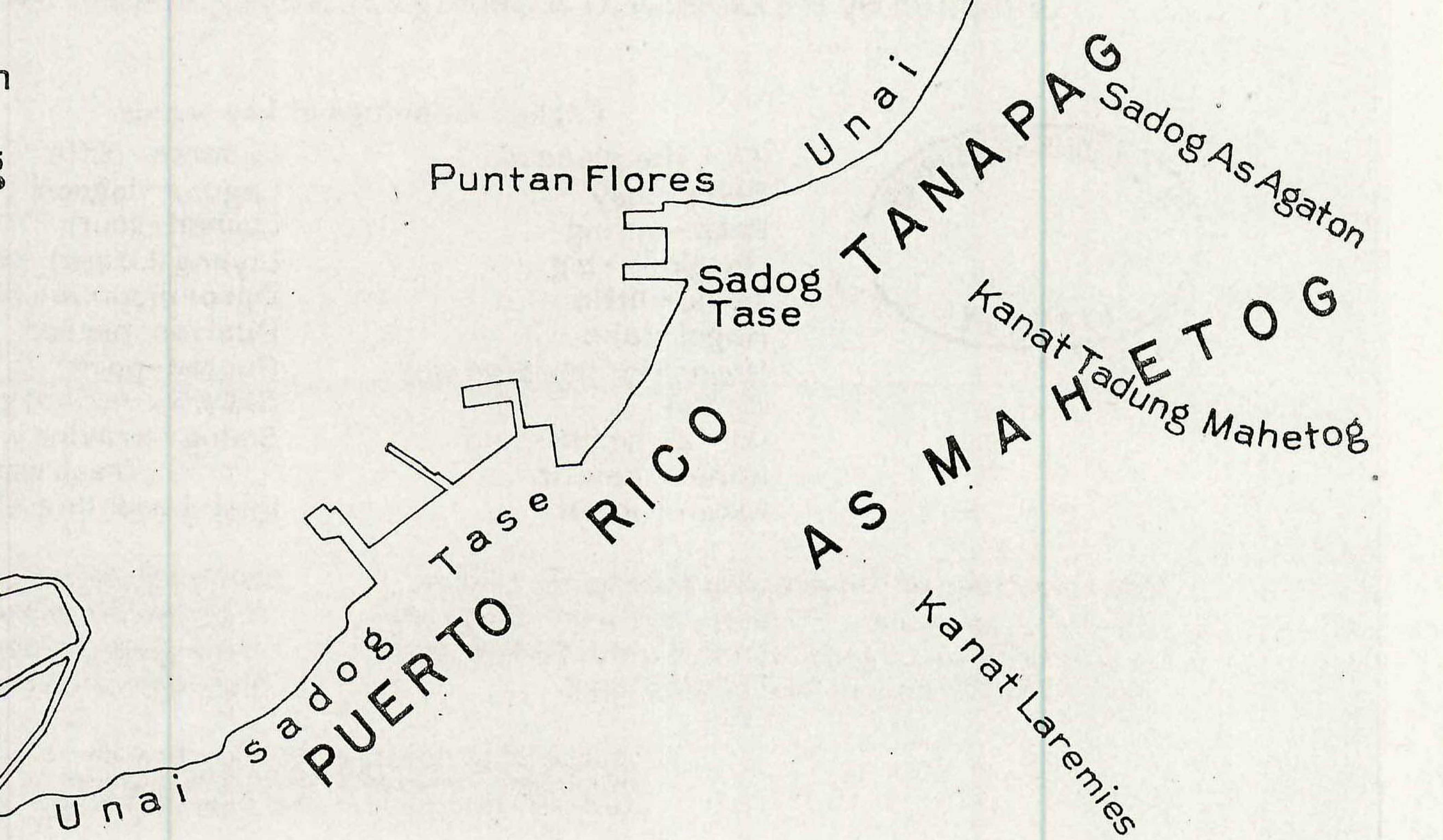
Puntan Flores
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AS MAHETOG
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Tase
Sadog
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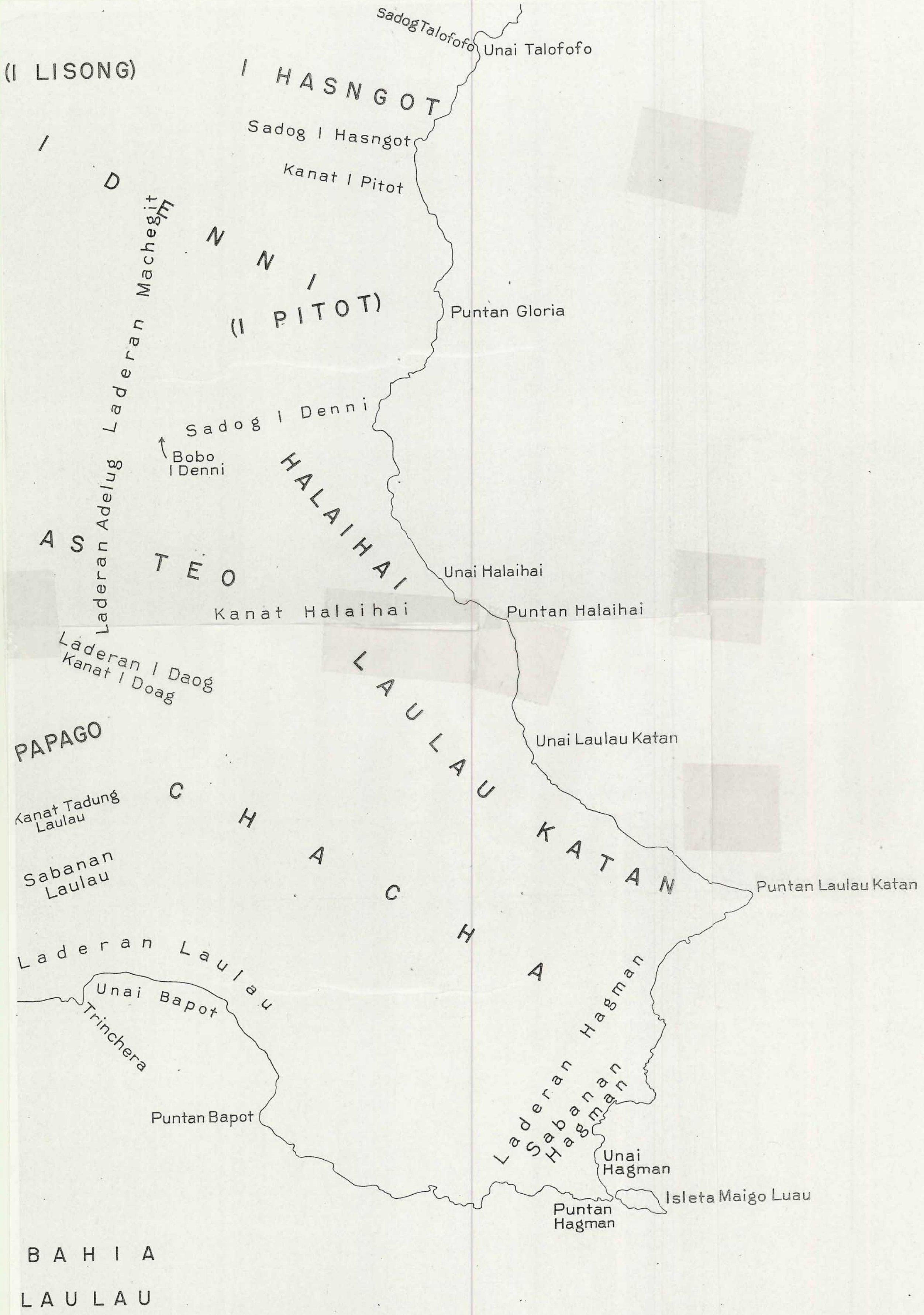
Kanat Laremies



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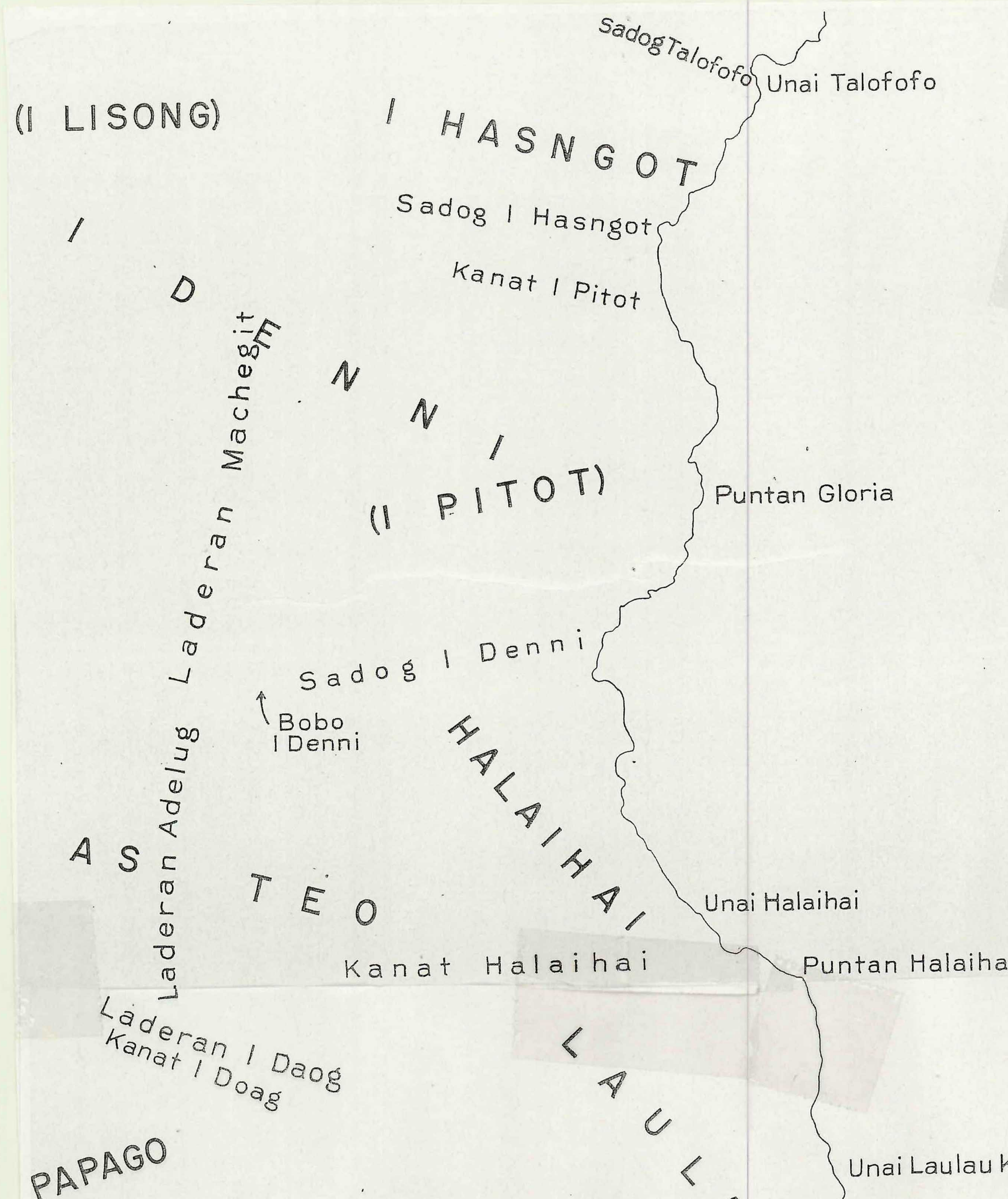

Sadog Talofofo
Unai Talofofo
(I LISONG)
I HASNGOT
Sadog I Hasngot
Kanat I Pitot
I DENNI
(I PITOT)
Laderan Machegit
Laderan Adelug
Puntan Gloria
Sadog I Denni
Bobo I Denni
HALAIHAI
AS TEO
Unai Halaihai
Kanat Halaihai
Puntan Halaiha
Laderan I Daog
Kanat I Doag
LAUL
PAPAGO
Unai Laulau

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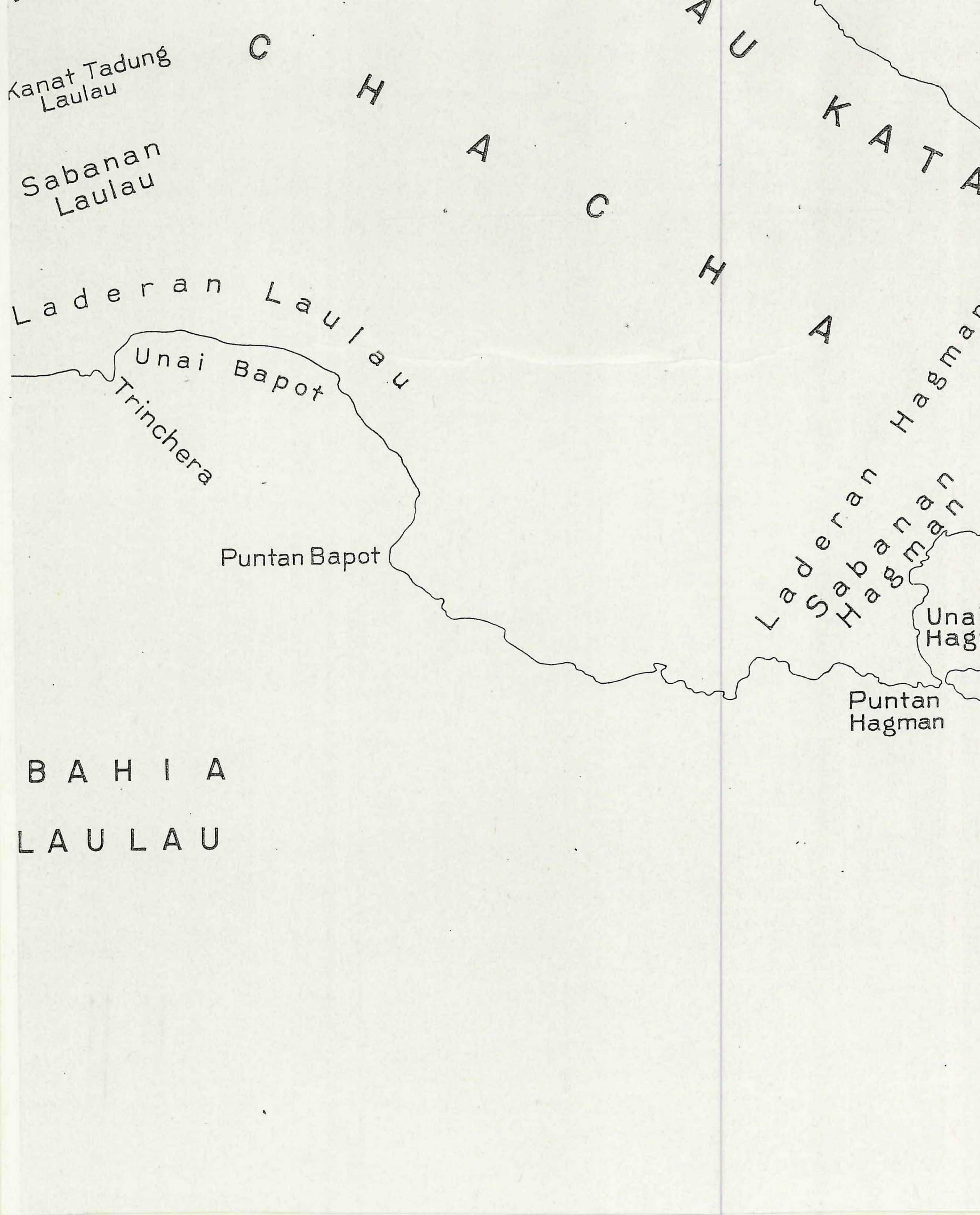
Katan



Kanat Tadung
Laulau
Sabanan
Laulau
Laderan Laulau
Unai Bapot
Trinchera
Puntan Bapot
CHACHA
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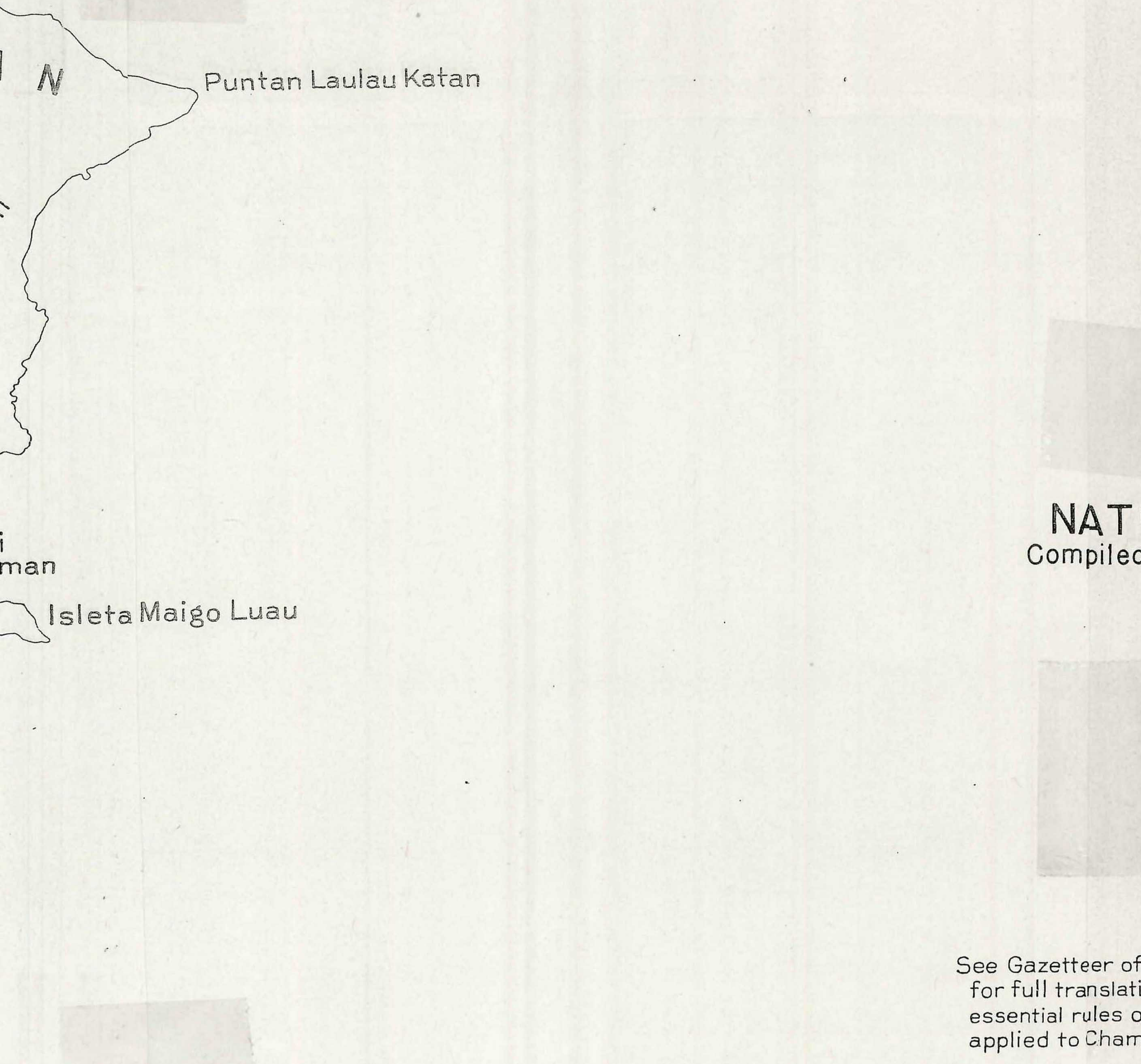
Laderan Hagman
Sabanan
Hagman
Puntan
Hagman
BAHIA
LAULAU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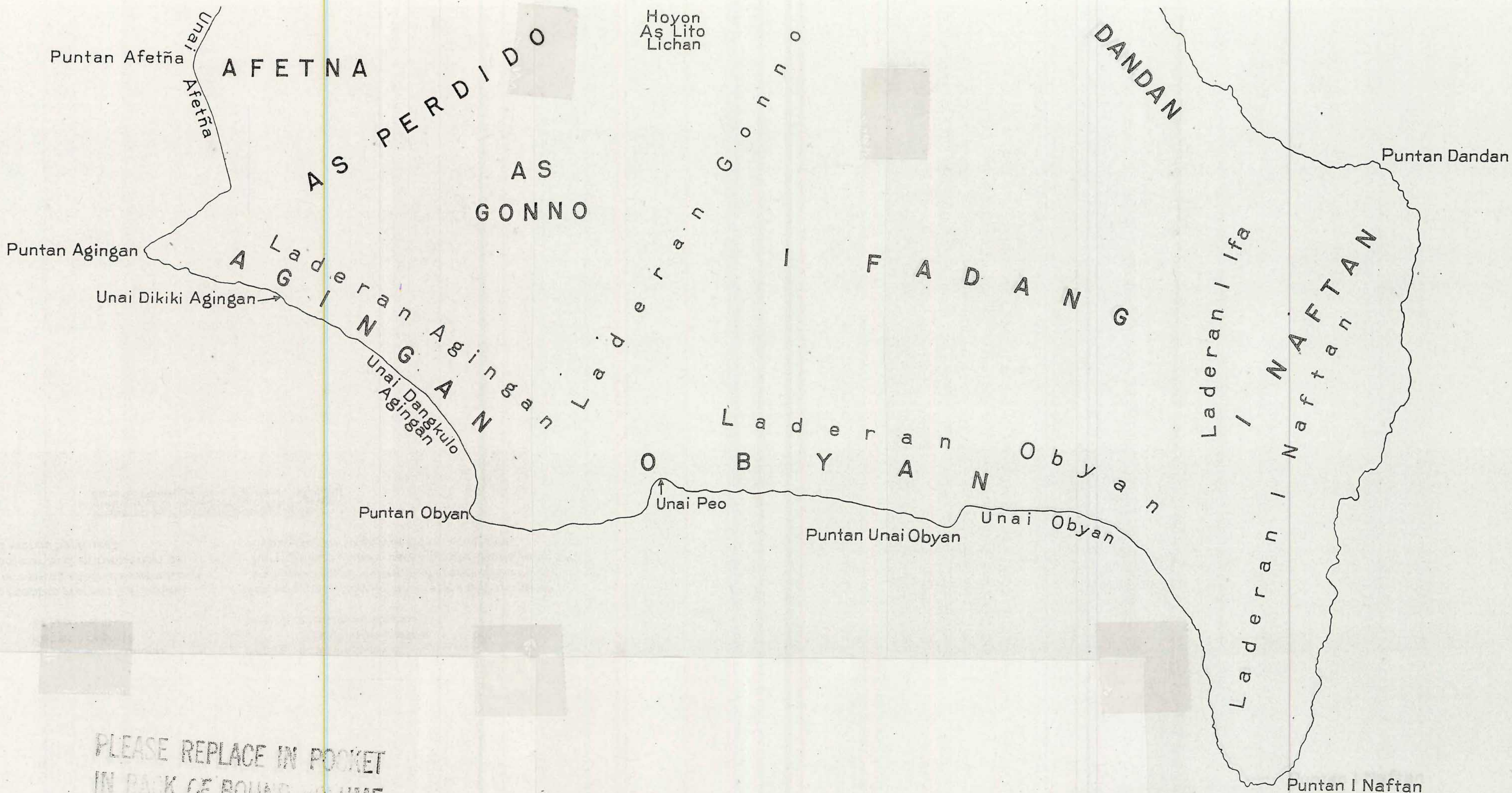

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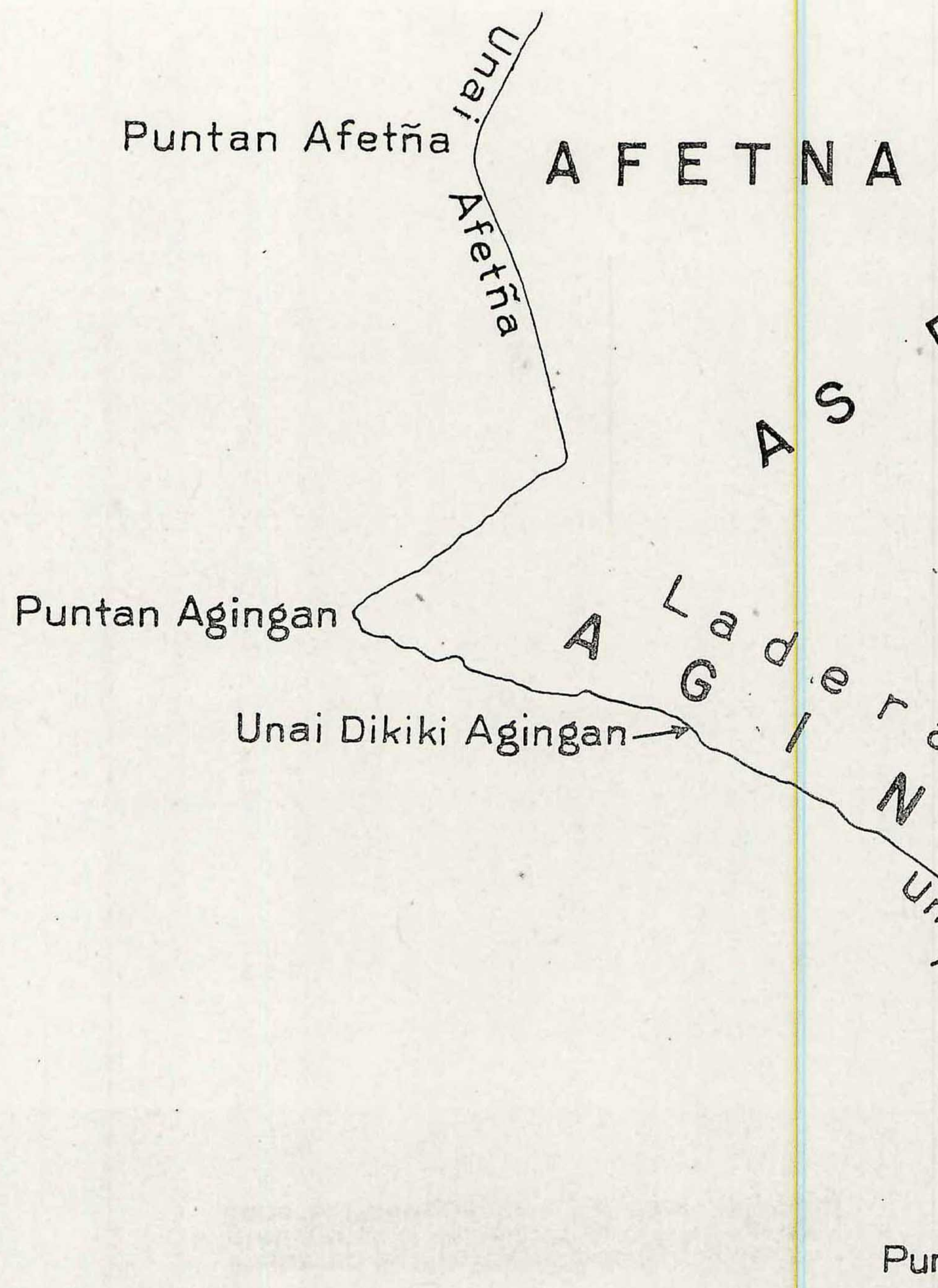
Unai
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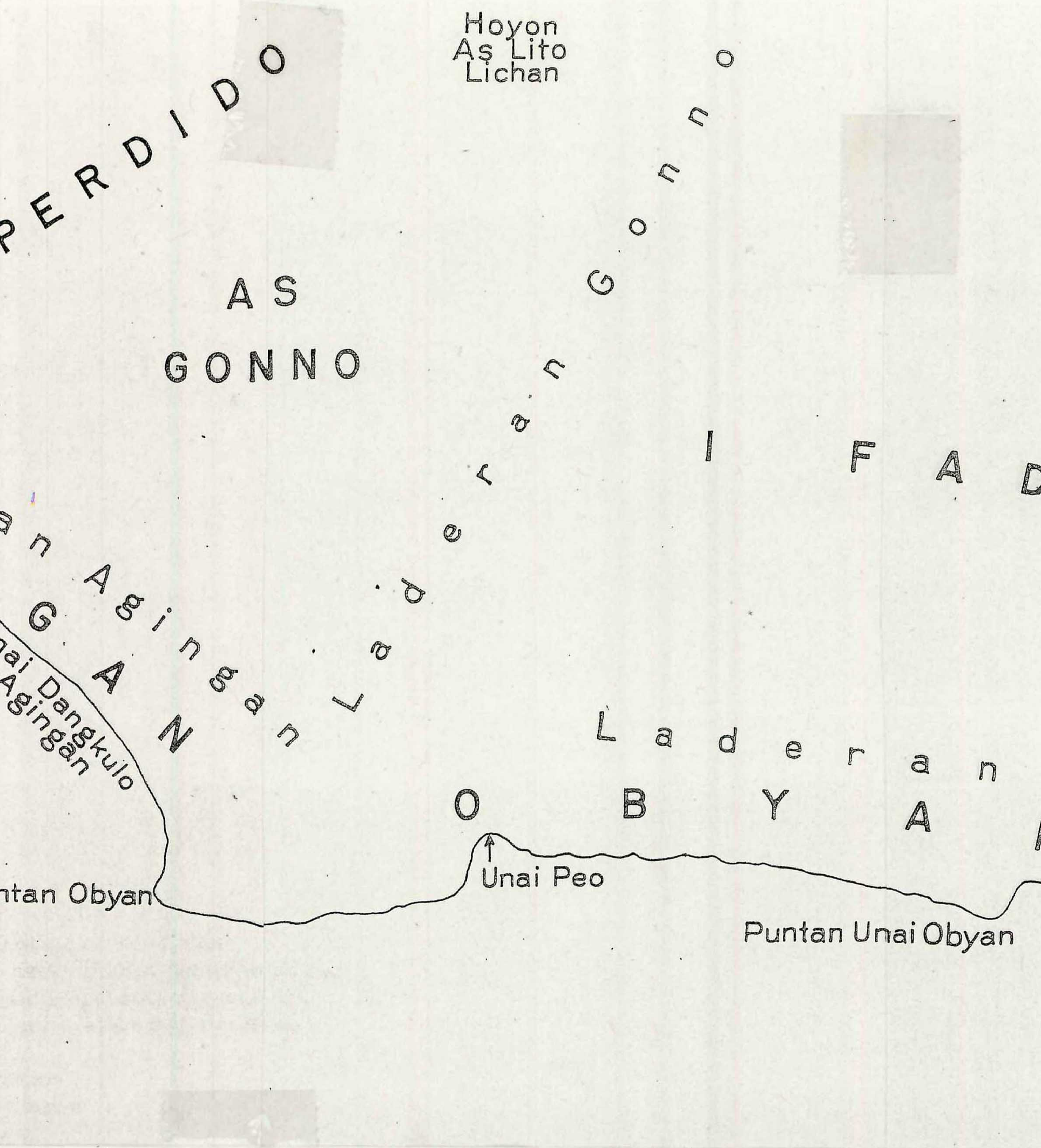
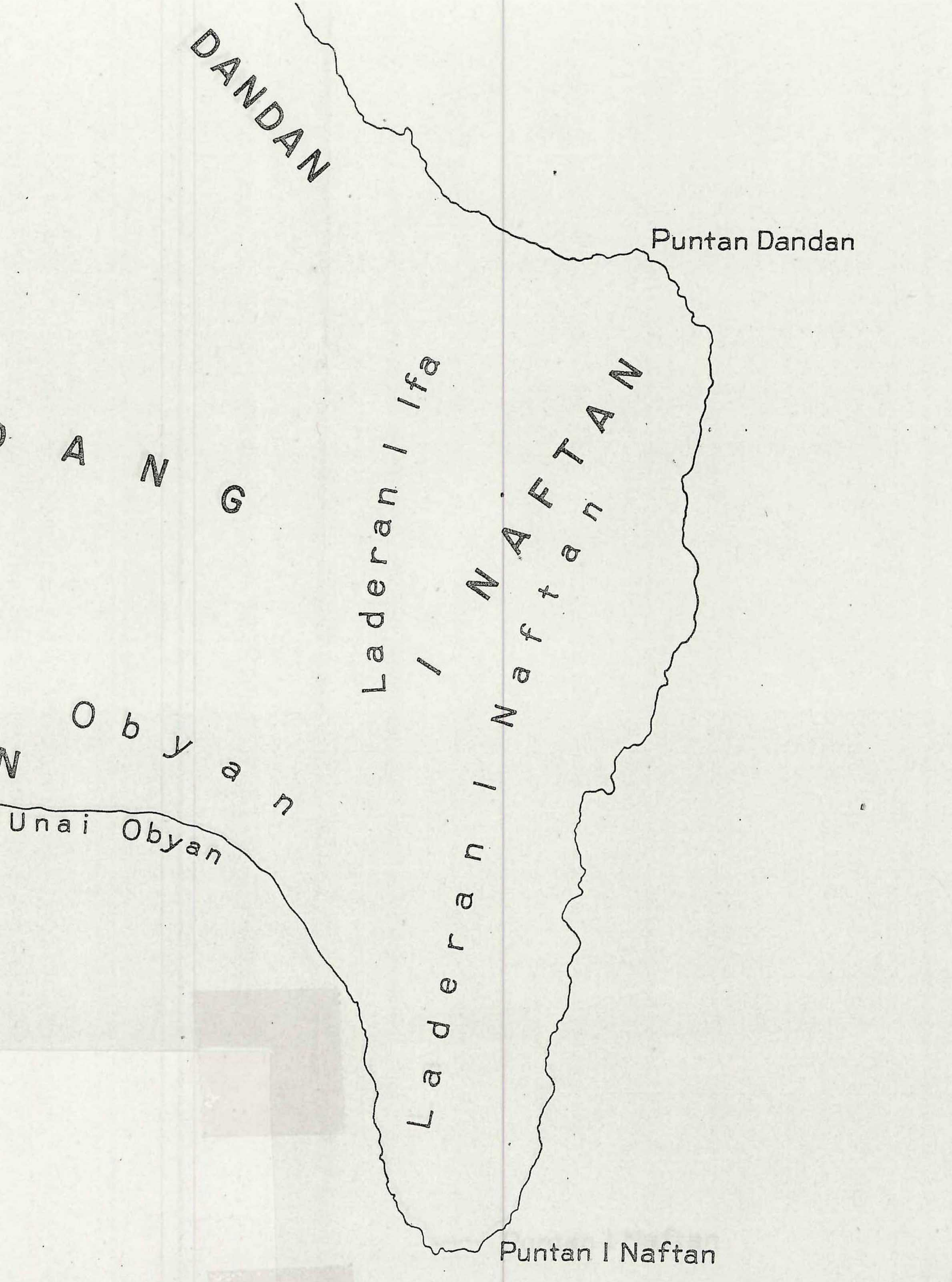
Puntan Afetña
AFETNA
Puntan Agingan
Unai Dikiki Agingan


Hoyon
As Lito
Lichan
PERDIDO
AS
GONNO
Laderan Gonno
I FAD
Laderan Agingan
GAN
Unai Dangkulo Agingan
Laderan
O B Y A
Unai Peo
ntan Obyan
Puntan Unai Obyan


DANDAN
Puntan Dandan
DANG
N
Obyan
Unai Obyan
Laderan I Ifa
NAFTAN
Laderan I Naftan
Laderan I Naftan
Puntan I Naftan

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